AN ARCHITECTURE FOR DYNAMIC PLANNING AND EXECUTION USING LOOSELY COUPLED COMPONENTS

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Background
The Loosely Coupled Components Project is a faculty/student research effort that is designing, developing, and validating a software architecture for advanced military planning and execution. The architecture supports the rapid construction of systems for planning and execution that operate seamlessly over a global network of heterogeneous computing devices and software systems. The architecture coordinates a collection of components that operate on a computer network (for example, the Internet, NIPRNet, or the SIPRNet) to access unit or location data, maps, overlays, algorithms and other information. The components perform tasks such as: displaying maps, satellite images, and overlays; accessing, entering, and modifying data; constructing and displaying models of military operations; and accessing and executing algorithms to analyze operations. The components are designed and constructed independently of each other and they can be combined rapidly and inexpensively to build a wide variety of tools for military planning and execution. The design allows systems to be easily extended by adding additional components.

   The fundamental research question is how to effectively use emerging commercial off-the-shelf (COTS) information technology to build advanced military systems for planning and execution with the capabilities envisioned in Joint Vision 2010, the Air Force's New Worlds Vista, the Navy's Quantum Leap, Army XXI Advanced Concept Technology Demonstrations (ACTDs), and other studies of warfare in the next century. The potential for the military is clear. However, like the technology advances of the past (steam powered ships, telegraph, radio, tanks, planes), it is not clear precisely how the technology can be incorporated into military planning and operations. It is even less clear how strategy and tactics need to change to best utilize the new capabilities. The United States has a definite advantage because of our economic resources and access to new technology. However, COTS technology, by its very nature, is also available to our potential adversaries. And military history is replete with examples of sudden shifts in relative military power because one military was able to more quickly understand the most effective way to use new technologies (for example, the tank and blitzkrieg, the plane and carrier based aviation, or radar and air defense).

Office of the Dean of Research   •   Naval Postgraduate School   •   Monterey, California

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
OCT 1998		**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Naval Postgraduate School Research. Volume 8, Number 3, October 1998	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Naval Postgraduate School ,Monterey,CA,93943	

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE		**44**	
unclassified	**unclassified**	**unclassified**			

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The post Cold War era is characterized by a wider spectrum of possible military missions, from Major Theater War (MTW) to Small Scale Contingencies (SSC) to Peacekeeping Operations (PKO), and by greater uncertainty about when and where military response will be required. This has generated requirements for flexible planning tools that support rapid response to situations whose details cannot be anticipated. These requirements are extensive. The planning resources (people, data, computers) will be distributed over a disparate, global network that has a range of computers (from supercomputers to cellular phones) and different software (operating systems, databases). The decision cycles will be much shorter, meaning the systems planning and execution need to work much faster with less time to make and review plans. Furthermore, there is a requirement to provide automatic monitoring of the planning and execution processes. The problems faced by planners will be less predictable than in the past, so the systems must be more flexible to address situations the designers cannot anticipate. The systems must have an open architecture that allows additional capabilities to be added without disruption. Legacy systems for planning and execution are too static, monolithic, and inflexible to meet these requirements. Current efforts to integrate legacy planning tools are an improvement, but, even when these efforts are brought to fruition, the results will not be sufficiently interoperable, platform independent, or extensible to meet the challenges of military decision making. As demanding as the individual requirements are, advanced systems for planning and execution must incorporate all these capabilities in an integrated system.

About the INVESTIGATORS

Gordon H. Bradley is a Professor of Operations Research. His research interests are in mathematical programming and software development. He has worked on integer programming and network optimization. Currently he is working on the design and development of a software architecture for dynamic map-based military systems for planning and execution using new platform-independent technologies. He teaches the Operations Research Department's Java course and advanced seminars in applying information technology to operations research problems.

Dr. Bradley received his Ph.D. from Northwestern University in 1967 followed by postdoctoral study at Stanford University. His first academic appointment was at Yale University where he was Assistant and then Associate Professor of Operations Research with a joint appointment in Computer Science. He joined the Operations Research Department at the Naval Postgraduate School in 1973. From 1977 to 1987 he was Professor of Computer Science including five years as Chair. Since 1987 his appointment has been in the Department of Operations Research.

Arnold H. Buss has taught and performed research in simulation analysis for eleven years. For the

Gordon Bradley

Arnold Buss

past four years he has been a Visiting Professor in Operations Research at the Naval Postgraduate School, where he has taught simulation and computer programming and supervised a number of student theses emphasizing simulation modeling.

Professor Buss has conducted research in component-based simulation modeling and simulation output analysis, as well as in manufacturing, project management and capacity planning. Current work includes simulation modeling in Java,

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Design of the Loosely Coupled Components Architecture

The basic architecture group is composed of the authors plus **MAJ Arent Arntzen**, Norway AF (MS in OR, September 1998) and **MAJ Leroy Jackson**, USA, US Army TRADOC Analysis Center-Monterey (Ph.D. candidate in OR). Each member of the group is working on different components; the group meets weekly to develop and refine the architecture and to review the design of the components. The group studies the emerging research on software components. The design proceeds by adopting where possible and developing where necessary the principles that underlie the design. The architecture specifies how individual components will interact (through mediators) and how components will be composed to produce larger components. At every level of composition, the compo-

nents have the same interface to other components. The programming language choice, Java, offers many advantages. Java is a good object-oriented language that supports composition through its "interface" construct and it contains powerful reflection and remote method execution capabilities that are used heavily in our work. The group studied Java's component technology, called Java Beans, very carefully, but ultimately decided it was not adequate for the dynamic composition that is necessary for our systems. We thus were lead to develop our own component design, which we have refined and validated by constructing several demonstration systems.

This component design currently consists of three major parts: the König package for creating graphs and interfaces for running algorithms on the graphs; an Application Programming Interface (API) for visually representing

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distributed simulation on the Internet, and component standards and frameworks for simulation modeling. He is a member of INFORMS, POMS, and IIE. He is an Associate Editor for *IIE Transactions* and is on the Editorial Review Board for *Production and Operations Management*. He has published papers in journals such as *Operations Research, IIE Transactions, Decision Sciences, Mathematical Problems in Engineering*, and the *Journal of Wind Engineering and Industrial Aerodynamics*.

Professor Buss received his B.A. from Rutgers University, M.S. degrees from the University of Arizona and Cornell University, and a Ph.D. from Cornell University. He is a member of Phi Beta Kappa, and was the recipient of the McMullen Graduate Fellowship and the Sage Graduate Fellowship while at Cornell University.

Charles H. Shaw, III is a Lieutenant Colonel, Quartermaster, in the United States Army currently serving as a Military Instructor in the Department of Operations Research and Fellow with the Institute for Joint Warfare Analysis (IJWA). His research and teaching interests include Joint and Combined Operations, Combat Modeling and Simulation, Joint and Combined Operational Logistics, Special Operations, Logistics Distribution Systems, and Military Operations Other Than War (MOOTW). He has served in this capacity since 1995.

LTC Shaw received a B.S. in Engineering from the U.S. Military Academy at West Point, NY in 1979 at which time he was commissioned as a Lieutenant in the Armor/Cavalry Branch. He received a M.S. in Operations Research from the Naval Postgraduate School at Monterey, CA in 1989. Prior to his current assignment, LTC Shaw served as the Battalion Executive Officer/Deputy Commander, 193rd Combat Support Battalion (Airborne); Commander, 193rd Brigade Material Management Center; Chief, Logistics Plans and Opera-

tions Division, J4; and Chief, Readiness and Force Integration Branch, J4 in the U.S. Army South and Joint Task Force - Panama located at Fort Clayton, Republic of Panama. Other previous assignments include Senior Operations Research Analyst, Defense Logistics Agency at Cameron Station, VA before, during, and after Operations Desert Shield/Storm and multiple assignments as an Armor/Cavalry Officer and Logistician at the tactical level in the United States, Germany, and Middle East.

LTC Charles Shaw, III

SIMULATION OF BIODYNAMIC RESPONSE TO UNDERWATER EXPLOSION EVENTS

Professor Young S. Shin
LT Douglas B. Oglesby, USN
Department of Mechanical Engineering

Background and Goals

NPS has been involved in research on "Underwater Explosions and Its Effects on Naval Ships" since 1983. Research on the effects of underwater explosions to surface ships and submarines has been active in the U.S. since World War II. The response of the ship's structural system, contained equipment, and weapons system subjected to an underwater explosion has been extensively investigated from the standpoint of susceptibility, vulnerability and survivability. However, in evaluating a ship's ability to remain a viable warfighting asset, crew survivability must also be addressed. For a ship to remain capable of fighting following damage resulting from enemy munitions such as mines or torpedoes, the ship's crew must remain sufficiently uninjured to be able to employ the weapons systems and fight the ship. This article is based on recent research at NPS concentrating on investigating the effects of underwater explosions on shipboard crew vulnerability.

The research has three basic goals: (i) to develop a method for estimating crew survivability to underwater explosion, (ii) to use accelerometer data and video footage taken during live fire testing as a basis for the simulation, and (iii) to perform injury estimates for both male and female crew members.

The Articulated Total Body (ATB) Program [1] was used and it was primarily designed to simulate the three dimensional response of a system of rigid bodies subjected to dynamic applied and interactive contact forces. The ATB program was also developed to model the response of crash test dummies, but is used in many varied applications

About the INVESTIGATOR

Young S. Shin is a Professor of Mechanical Engineering. He received his undergraduate degree from Seoul National University followed by his Ph.D. from Case Western Reserve University. Before joining NPS in 1981, Dr. Shin was with General Electric and Argonne National Laboratory.

Dr. Shin's primary teaching interests are dynamics, machine design, classical and random vibrations, and naval ship shock analysis and design. His research interests are shock and vibration analysis and design including underwater explosion testing and simulation, noise and vibration control and machinery monitoring and diagnostics. His current work extends to Ship Shock and Biodynamic Response Simulations to Underwater Explosions.

Dr. Shin is a Fellow of the American Society of Mechanical Engineers.

Douglas B. Oglesby is a Lieutenant in the United States Navy and a former graduate student of NPS. He received his undergraduate degree from the University of Missouri-Rolla followed by his Mechanical Engineer's degree from NPS. His thesis research was under the guidance of Professor Shin. LT Oglesby was recognized with three awards upon graduation: the Monterey Council Navy League Award for Highest Academic Achievement, the Naval Sea Systems Command Award in Naval/Mechanical Engineering, and the Surface Navy Association's Award for Excellence in Surface Warfare Research.

Young S. Shin

UNDERWATER EXPLOSION, *continued from page 4*

including human body motion, transient response of a MX missile in a wind tunnel, and pilot ejection from aircraft [1]. Use of the ATB program to model the response of a human in a shipboard environment is not quite different from using it to model the responses of a human or test dummy in an automobile or aircraft crash. Once a model is developed of the environment, the result of changes to the input excitation, such as improved shock isolation or varied charge size/location can be estimated and potential injuries predicted.

Experimental Set-up and ATB Model

This study relied on data for vehicle excitation and dummy response provided by the Naval Surface Warfare Center - Carderock Division. The data is from the Site Phase 3 (SSTV) Shock Test series, Shot 9991, conducted in June 1996. The anthropomorphic test device (ATD) modeled in this study was a Hybrid III 50th percentile male dummy [2] instrumented with triaxial linear accelerometers located at the centers of gravity of the head, thorax, and pelvis. The ATD was seated, lap belt securely fastened, facing starboard in a standard operator's chair on the upper platform of a two platform test vessel that was subjected to an underwater explosion event. The test vessel was equipped with linear accelerometers. Accelerometers oriented in the vertical and athwartship directions were located at the base of the chair and the measured output was used as the basis of the excitation used in the ATB model.

A model of the operator's chair, based on measured physical dimensions, was constructed in the ATB program using plane contact surfaces for the seat pan, sides and back, and using contact segments for each arm rest. Force-deflection, energy absorption and damping properties for the seat surfaces were estimated. The physical dimensions, inertial properties and joint characteristics for the Hybrid III dummy were used directly as generated by the Generator of Body Data (GEBOD) program [3]. The model of the dummy was positioned in the simulation to match as closely as possible the position of the dummy as seen in the video of the test.

Hybrid ATD Dummy: Measured and Predicted Response

Evaluation of the accuracy of the ATB model was made by comparing the accelerations of the head, thorax, and pelvis as predicted by the simulation to the measured values. In addition, the gross body motion as predicted by the simulation was compared to still frame images captured from standard video taken of the dummy during the underwater explosion event. Modifications were made to the initial position of the dummy and the characteristics of the chair in the simulation until reasonable agreement was obtained between accelerations and gross body motion. Figure 1 shows the sign convention used in reporting the accelerations of the head, thorax, and pelvis. As motion was predominantly in the sagittal plane and no lateral input acceleration (fore-and-aft) was used in the model excitation signal, accelerations in the Y direction were not compared.

Figure 1. Dummy Coordinate System [3]

Quite good overall agreement was seen in both the head X and Z directions (Fig. 2 and 3), with the phasing consistent and the many of the amplitudes closely matched. Agreement in the chest X direction (Fig. 4) is not as good, but the chest Z results (Fig. 5) show good phasing response even though the magnitudes in the peaks are for the most part under-estimated. Similarly, the pelvis X results (Fig. 6) are not as closely in agreement as the pelvis Z results (Fig. 7) which show good agreement both in phasing and amplitude.

INFORMATION SYSTEMS ACADEMIC GROUP FOCUSSES ON INFORMATION SYSTEMS, ENGINEERING AND MANAGEMENT

Information Systems (IS) is the name of a newly formed Academic Group at NPS within the Division of Computer and Information Sciences and Operations. The IS Academic Group is comprised of faculty with diverse backgrounds in Information Sciences, Systems and Information Technology Management, a key component of the Information Sciences, Systems and Operations Curricula being brought on-line. The impact of information systems in the military environment covers many areas. A wide variety of research is being pursued by the IS faculty ranging from

Network Centric Warfare to medical evaluations of Persian Gulf War veterans.

Associate Professor **Hemant Bhargava** is working on a project with the U.S. Marine Corps (Manpower and Reserve Affairs) to reengineer and reimplement their various manpower planning models using more modern computer-based modeling technology. Professor Bhargava's effort will allow better interoperability and model reuse, better data management and model management, with an improved user and control interface. Models being studied include the Target Force Planning Model, Manpower Level Process, Officer Planning Utility System, Enlisted Planning System, Enlisted Staffing Goal Model, Recruit Distribution Model, Enlisted Assignment Model, Marine Equity Model, and the Officer Staffing Goal Model. Current work has

INFORMATION SCIENCES, SYSTEMS AND OPERATIONS CURRICULUM

A recent initiative undertaken by the Naval Postgraduate School started as a response to conversations with VADM Cebrowski, the previous Director of Space Information Warfare, Command, and Control (N6). N6 is the sponsor, directly or indirectly, for several curricula— Joint Command, Control, Communications and Intelligence Systems (JC4IS), Space Systems Operations (SSO), Information Technology Management (ITM), Modeling, Virtual Environments, and Simulations (MOVES), Computer Science (CS) and Information Warfare (IW). Coupled with the overall impact of C4ISR systems in the military environment and the creation of Network Centric Warfare, VADM Cebrowski's concern for better utilization and flexibility in assigning officers in graduate education coded billets prompted N6 and NPS to create a uniquely tailored Information Sciences, Systems and Operations curriculum. This new curriculum, with specializations in CS, JC4IS, SSO , ITM, MOVES and IW and a Professional Practice Core, is designed to serve warfighters and technical support officers with knowledge and understanding as follows:

- Understand and innovatively create, maintain, and operate doctrine, systems, and procedures to assure our Information Superiority.
- Understand and innovatively develop and implement command and control decision processes in organiza-

tions to assure Information Superiority.
- Understand and innovatively employ Science and Technology in creating systems for Information Superiority.

As an additional part of the N6/NPS graduate education initiative, VADM Cebrowski also directed the creation of an information operations oriented curriculum for the URLs. This five-quarter curriculum is currently under development. While the specifics will evolve (including the official name), VADM Cebrowski has approved the educational skill requirements. The graduate of the "Information Sciences and Operations Curriculum" shall:
- Understand and innovatively create strategies and policies using military and commercial conceptual models and assets for information operations.
- Understand and innovatively create agile organization structures and decision processes responsive to real time mission and situation requirements.
- Understand information technology and systems as a provider of opportunities to gain information superiority and perform information operations.
- Be able to integrate technology, organization, policy and strategy into an information operations framework and to use it in deliberate and crisis planning and execution across the range of military operations.
- Each graduate will demonstrate the ability to identify and solve a significant information operations problem and communicate the result in writing and in a command-oriented briefing.

focussed on the Enlisted Assignment Model that assigns enlisted Marines to jobs and the Recruit Distribution Model. However, Dr. Bhargava recently presented a broader picture on the use of scientific methods (embedded in decision models and computer-based information technologies) in decision making to the USMC Manpower and Reserve Affairs' flag officers.

Dr. Bhargava and students **LT Clay Tettelbach**, USN, **LTChris Corgnati**, USN, **LTJG Devrim Rehber**, Turkish Navy, **LCDR Craig Herrick**, USN, and **Major Michael Broihier**, USMC, have worked on the integration of decision technologies and internet computing, resulting in the development of decision technologies that can be accessed and used over the internet. The Recycling Decision Support System is a special case of a web-based decision technology and is available at http://dnet.sm.nps.navy.mil/webdss/. DecisionNet, a virtual repository and electronic brokerage of such technologies, is available at http://dnet.sm.nps.navy.mil/.

Attempting to discover relationships and patterns that may provide answers to health problems reported by Persian Gulf War veterans, Dr. Bhargava, working with the Office of the Assistant Secretary of Defense for Health Affairs, analyzed a database containing demographics, attributes and results of comprehensive medical evaluations of the veterans. Applying conventional and emerging data analysis techniques, he developed a novel approach which provides a general purpose system for exploratory data analysis.

The Navy establishment is currently engaged in the Naval Virtual Intranet Program that will see the Naval Communications System rebuilt on an internet model and the Naval Computer and Telecommunications Stations (NCTS) as internet service providers. This is the first true rebuild of the NCTS since WWII. Lecturer **Rex Buddenberg** has been involved with the project since its programmatic beginning, serving directly on two Integrated Product Teams. One of his students, **LCDR Peter Vena**, USN, has completed his thesis on enlisted IT rates needed to sustain the infrastructure.

Professor **Daniel Dolk** is working with the Navy Personnel and Research Development Center and the Office of Naval Research on a project to build a Personnel Battlefield Simulation (PBS) System. PBS will allow people in the manpower community to play the simulation, try out

REENGINEERING THE UNITED STATES MARINE CORPS' RECRUIT DISTRIBUTION MODEL (RDM)
Lieutenant Kevin J. Snoap, United States Navy
Masters of Science in Information Technology Management-September 1998
Advisors: Associate Professor Hemant K. Bhargava and Assistant Professor Suresh Sridhar, Information Systems Academic Group

The United States Marine Corps accomplishes its mission "to put the right Marine in the right place at the right time with the right skills and quality of life" in a variety of ways. One of the information systems assisting the Marine Enlisted Assignments Branch is the Recruit Distribution Model (RDM). This thesis proposes changes to the RDM user interface, data management, assignment model, and analysis capability. With the use of business process reengineering, process modeling, mathematical modeling, and database design, a fully functional prototype has been developed to address each identified change proposal. This reengineered system includes numerous innovations such as an intuitive navigational scheme using switchboards, and the elimination of manual data entry for data already available in the system. It also provides a number of significant contributions beneficial to the USMC. For instance, the reengineered system allows the user to objectively analyze different results by comparing four different objective measures, and its mathematical model uses commercial-off-the-shelf products eliminating a proprietary solver. All these changes will empower managers to effectively and efficiently manage the assignment of recruits in order to meet the challenges of the 21st century.

different policies, e.g., close 20% of current recruiting stations, and see the effects of their decisions in terms of budget terms and force readiness terms. The system will be Web-based, map-driven, and will require the integration of multiple existing Navy manpower models in the areas of

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recruiting, assignment and distribution, force strength, manpower requirements, and training management.

Professor **Carl Jones** and Associate Professor **Kishore Sengupta** are conducting research on the organizational

and command and control aspects of Network Centric Warfare. Recent thinking on warfighting has laid increasing stress on the concept of Network Centric Warfare. Network Centric Warfare envisages creating organizations that are agile with speed of command and self-synchronization. Research is now ongoing to understand the principles needed to guide the commander in creating and leading such a command. Using the principles of self-organizing systems from organization theory and complexity theory and shaping them into design guidelines for mapping command and control processes to the needs of specific missions, Dr. Jones and Sengupta are working towards a "primer" of concepts, principles, and design guidelines for planning and organizing.

Seventeen students have worked with Associate Professor **Magdi Kamel** and Visiting Research Professor **Martin J. McCaffrey** to develop an expert system to assist and advise the MK92 technician in diagnosing and resolving problems occurring in the Fire Control System (FCS) MK92 Mod 2 onboard the FFG-7 Class ships. Sponsors and collaborators on this applied project have included the Naval Sea Systems Command, the Naval Scientific Assistance Program, and the Naval Surface Warfare Center.

A recent trend in the field of information systems is the development and deployment of Intranets, i.e., using World Wide Web (WWW) technology to support planning, administration, and control internal to an organization. Assistant Professor **Suresh Sridhar** has investigated new and innovative ways by which Internets can facilitate information

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THE MK92 MOD 2 FIRE CONTROL SYSTEM EXPERT DIAGNOSTIC SYSTEM PROJECT
Associate Professor Magdi Kamel, Information Systems Academic Group
Visiting Research Professor Martin J. McCaffrey, Institute for Defense Education Analysis

In 1992, the Naval Postgraduate School in cooperation with the Port Hueneme Division, Naval Surface Warfare Center initiated a long-term effort to develop an expert system to assist and advise the MK92 technician in diagnosing and resolving problems occurring in the Fire Control System (FCS) MK92 Mod 2 onboard the FFG-7 Class ships. The objective of the expert system is to perform as an onboard expert that emulates a subject matter expert's knowledge and methods in troubleshooting and resolving casualties in the MK92 system.

As of September 1998, three modules have been developed, tested, and deployed. The first two modules are to analyze and diagnose the FCS MK92 Daily System Operability Test (DSOT) results printout. The third module is for the evaluation and problem resolution of the RF Transmitter Power Checks.

To date the expert system has been deployed to eighteen U.S., six Australian, six Spanish, and three Egyptian Navy ships. Plans are under way to deploy the expert system to all US FFG-7 frigates as well as those in the Bahrainian and Turkish Navies. The initial development of the Mod 2 MAES is currently being ported to the FCS MK92 Mod 1 and Mod 5 systems for the deployment onboard Coast Guard and U.S. Navy Ships.

The FCS MK92 Mod 2 has been a challenging and costly system to maintain. In past years, the No Fault Evident (NFE) replacement of parts has been a serious problem. A review of 700 Casualty Reports (CASREPS) by NPS revealed that 22% of parts replaced were NFE. This translates to $900,000 per year in OPTAR. With the development of an expert system to aid and advise in troubleshooting FCS MK92 problems, a substantial savings in repair time and funds can be realized. Other key benefits of the expert system include improved operational readiness and reduced Mean Time to Repair. The expert system has provided technician-troubleshooting expertise where scarce, upgrades the diagnostic performance of less experienced technicians, and captured and preserved domain-troubleshooting expertise that would otherwise be lost.

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dissemination and sharing. Working with several thesis students to develop Intranet prototypes for various agencies of the Army, Marine Corps and Coast Guard, Dr. Sridhar's research has had direct application to current real-word issues**. Major Malcolm B. LeMay**, USMC, was recently commended by the Commanding Officer of the Marine Corps Tactical Systems Support Activity, (MCTSSA) for his thesis research on a MCTSSA sponsored project. In June 1996, the Air Defense Systems Division developed several possible thesis topics for Marine Corps students at NPS. Major LeMay tackled the project of designing and implementing Intranet services for the Air Combat Element (ACE) of the Marine Air Ground Task Force (MAGTF). In a letter to NPS, Col L.E. Troffer, Commanding Officer, MCTSSA, stated, "Major LeMay's research of ACE processes and the methodology he developed for the prototype will serve as an excellent model in developing other MAGTF related Intranet-based decision support tools. Major LeMay's thesis project is an excellent example of the return on investment the Marine Corps seeks in sending Marine Officers to NPS."

Other thesis projects under the direction of Dr. Sridhar have included a prototype on-line navigation planning tool for the Navy that has been dubbed "GatorNet," and an operational prototype intranet site for the California Army National Guard to allow members of the 40th Infantry Division throughout the state to pass information on readiness data.

Professor **Norman Schneidewind** continues his research on software reliability. The relationship between product quality and process capability and maturity has been recognized as a major issue in software engineering based on the premise that improvements in process will lead to higher quality products. To this end, Dr. Schneidewind has been investigating an important facet of process capability—stability—as defined and evaluated by trend, change, and shape metrics, across releases and within a release. His integration of product and process measurement and evaluation serves the dual purpose of using metrics to assess and predict reliability and risk and concurrently uses these metrics for process stability evaluation. The NASA Space Shuttle flight software has been used to illustrate the approach. Positive results have been obtained to integrate product and process evaluations in one model. **CDR Dennis Brophy**, USN, and **LCDR James O'Leary**, USN,

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INTRANET-BASED DECISION SUPPORT FOR THE MARINE AIR GROUND TASK FORCE AVIATION COMBAT ELEMENT
Major Malcolm LeMay, United States Marine Corps
Master of Science in Information Technology Management-September 1998
Advisors: Assistant Professor Suresh Sridhar and Associate Professor Barry Frew, Information Systems Academic Group

Information technology can be an effective force multiplier for the Air Combat Element (ACE) of the Marine Air Ground Task Force (MAGTF). Through the use of Intranet-based decision support, internet technology can be leveraged to improve the decision support and information processes of the ACE. This thesis reviews the objectives of Intranet-based decision support and provides a methodology to follow for implementing Intranet-based decision support for the ACE. The methodology combines systems development life cycle (SDLC) practices, command and control theory, an organizational analysis of the ACE and prototyping to achieve Intranet-based decision support. The results from a process analysis are evaluated to select suitable processes for migration to Intranet-based decision support. Prototype development involves coding approximately 100 software files in Cold Fusion. As part of the prototyping process, comments from fleet-based Marines are collected and incorporated in the prototype when possible. The methodology developed for this project could be used for other MAGTF related Intranet-based decision support systems.

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are pursuing the development of an enhanced network and tools for software reliability and metrics research. Two other ITM students, **LT Cameron Carney**, USN, and **LT Tony Ellis**, USN, are investigating the feasibility of employing Asynchronous Transfer Mode networking technology in the Software Metrics Research Center at NPS.

NPS' LEADERSHIP EDUCATION AND DEVELOPMENT (LEAD) PROGRAM AT THE U.S. NAVAL ACADEMY GRADUATES FIRST CLASS

The Leadership Education and Development (LEAD) Program was developed by NPS' Department of Systems Management in response to a need generated by the United States Naval Academy (USNA). The first class graduated from the U.S. Naval Academy in August with a Masters of Science Degree in Leadership and Human Resources Development. The graduates conducted thesis research on topics such as an examination of Navy OPTEMPO, prediction of performance and retention in the fleet, and the effects of leadership and ethics instruction on leader development. VADM John Ryan, Superintendent of the Naval Academy, was very pleased that the graduate students addressed issues that are important to the Navy and the Naval Academy.

Background

ADM Charles R. Larson, former Superintendent at the USNA, asked for proposals for graduate education for his Company Officers from several universities in the Annapolis area, including Johns Hopkins. The impetus for his idea was to professionalize the Company Officer billet, to attract high quality officers to fill it, and also to provide graduate education that would be useful to officers after they leave the Naval Academy.

The Company Officer is the person most closely involved in the development of midshipmen, with responsibilities ranging from disciplinarian to role model. The Company Officer, a Lieutenant or Lieutenant Commander, serves a two-year tour in charge of 130 midshipmen. Admiral Larson's concept required one year in full-time graduate education before taking charge of a company.

In response to the request for a proposal, NPS faculty initiated a needs analysis of the Company Officer job based on interviews and documentation. The result of the analysis was a set of educational skill requirements (ESRs), which were subsequently reviewed and endorsed by top leadership at USNA as an accurate reflection of the Company Officer position as well as the development of subordinates conducted by effective military leaders. Because of the relevance of the ESRs included in the proposal, the decision was made to have NPS develop and implement the program.

At this point, NPS faculty conducted a search for similar programs from which insight might be gained for developing courses to support the ESRs. While many programs have "leadership" in the title, most focus on teaching leadership rather than *leadership development.*

There is little in the way of graduate education, and—of course—none are customized for military relevance.

NPS proceeded with course development for the ESRs, and a final program was completed for approval by the NPS Academic Council and Western Association of Schools and Colleges. Both approvals were received and the first class began in August 1997. A second class started in June of this year.

The program consists of modules taught in one- or two-week periods, which—when completed—comprise NPS management courses for a total of 57 credits, and a thesis. Systems Management faculty travel to Annapolis for course offerings with some supplemental work done by VTC. This unique approach offers the following advantages:

• On-site education permits a working relationship to develop between graduate students and current Company Officers, which creates an opportunity to integrate course work with hands-on practice. Faculty have found many opportunities to create projects that draw on USNA examples of the academic concepts taught in the classroom. Linking academic work with hands-on practice and real-world examples should produce superior retention of the concepts learned and, therefore, superior transfer of learning to performance on the job.

• Providing graduate education where the payback tour occurs saves Navy resources.

• Frequent contact between NPS faculty and USNA sponsors provides instant feedback on program direction and effectiveness.

• Students have the opportunity to utilize USNA resources, e.g., institutional data, for thesis research to address issues important to the Navy and the Naval Academy.

DETERMINANTS OF FLIGHT TRAINING PERFORMANCE: NAVAL ACADEMY CLASSES OF 1995 AND 1996

Lieutenant Paul M. Reinhart, United States Navy
Master of Science in Leadership and Human Resources Development-August 1998
Advisors: Visiting Associate Professor Gregory G. Hildebrandt, Department of Systems Management, and Roger D. Little, U.S. Naval Academy

This thesis investigates the relationship between observable characteristics and performance during the primary stage of flight training. The data for this study consists of 272 observations from Naval Academy graduates in the classes of 1995 and 1996. Analysis of the variables was conducted using the Heckman two-stage regression technique to correct for possible selectivity bias. In this technique a first-stage probit model, which predicts the likelihood of primary phase completion, is used to generate a correction factor for possible selectivity bias. The correction factor is then used in the second-stage adjusted least-squares regression model. The conclusions of this study are: 1) the biographical inventory from the Aviation Selection Test Battery (ASTB) is a valid predictor of primary phase completion, and 2) the Pilot Flight Aptitude Rating (PFAR) from the ASTB, academic achievement (AQPR) at the Naval Academy, and previous flight experience are all valid predictors of flight training performance. Additionally, it appears that sample selection bias does not seem to be a problem in this analysis.

THE RELATIONSHIP BETWEEN ACADEMIC MAJOR AT THE UNITED STATES NAVAL ACADEMY AND SERVICE COMMUNITY SELECTION

Lieutenant Brian K. Arcement, United States Navy
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This study provides information for those individuals responsible for guiding midshipmen's choice of naval service community. This research focused on individuals who received their first community choice. The analysis demonstrates that choice of academic major frequently affects the likelihood that an individual will select a particular community. For example, a shift from a group one major to a group two major significantly decreases the likelihood of selecting the Marine Corps. Another finding is that a shift from group one major to either group two or group three majors decreases the likelihood of selecting submarines. The fact that it is possible to predict community choice from academic major may not be obvious to midshipmen when they choose their major during the second semester of their plebe year. This project was designed to provide company officers with the information needed to counsel midshipmen about the service community available following graduation from the Naval Academy. The choice of career field is the culmination of four years of hard work by midshipmen, and this decision can affect their naval service career for many years.

POST-COLD WAR PERSTEMPO POLICIES AND CHALLENGES: AN EXAMINATION OF THE BASELINE ENGAGEMENT FORCE ASSESSMENT AND MODEL

Lieutenant Wayne G. Grasdock, United States Navy
Master of Science in Leadership and Human Resources Development-August 1998
Advisors: Associate Professor Richard B. Doyle and Lecturer Walter E. Owen, Department of Systems Management

This thesis addresses the policy and analytical challenges associated with the post-Cold War personnel tempo (PERSTEMPO). It examines a study conducted by the Joint Staff called the Baseline Engagement Force (BEF) Assessment. The majority of the data were obtained from the Force Structure, Resources, and Assessment Directorate (J-8) of the Joint Staff. The BEF Assessment determined the level of military effort required to support peacetime engagement demands and revealed that PERSTEMPO reporting among the Services is diverse in that reporting and

AGREEMENT INITIATES COOPERATIVE RESEARCH AND DEVELOPMENT BETWEEN NPS AND THE NAVAL SURFACE WARFARE CENTER-CARDEROCK DIVISON

A Memorandum of Agreement to provide ties between NPS and the Naval Surface Warfare Center-Carderock Division, in the areas of naval vehicles (hull, mechanical and electrical) and logistics has been initiated with the aim of sharing research facilities and technical expertise. This sharing of assets, both human and physical, should provide the Navy with strong, technically well-integrated science and technology programs in these areas, as well as introduce future Navy officers to current state-of-the art practices in naval vehicle philosophy and design.

RELATIONSHIP ESTABLISHED WITH DIRECTOR OF NAVAL INTELLIGENCE

A Memorandum of Agreement between the Director of Naval Intelligence (DNI) and the Superintendent, Naval Postgraduate School, was recently signed to provide support to NPS for the DNI-sponsored intelligence curriculum and for student professional development. The DNI supports the enhancement and strengthening of naval officers in the academic intelligence subspecialty curriculum at NPS. To ensure that these naval officers become more familiar with, and exposed to, naval sites, facilities, and major C4I systems/nodes, specific supplements to the student curricula will be supported by the DNI.

NPS AND NRL FORM A CENTER FOR UNMANNED AIR VEHICLE TECHNOLOGY DEVELOPMENT

The Naval Research Laboratory (NRL) and NPS have entered into a cooperative agreement to foster the development of a joint program which will provide the Navy with the ability to effectively develop and utilize unmanned aerial vehicles (UAVs) for Fleet operations. The merging of the activities and capabilities of NPS and NRL will enable the formation of a Center for Unmanned Air Vehicle Technology Development. This Center will explicitly focus its efforts on the development and application of UAV technologies for the Navy. The considerable UAV flight assets of NPS' Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) will be utilized to promote UAV development, experimentation, database supplementation, and concepts of operations development. NPS plans to develop and offer tailored graduate courses and curricula which address all aspects of the UAV for military applications (design, testing, payloads, CONOPS, avionics, C4I, modeling and simulation, deconfliction, etc.). NRL will provide access to the base of scientific knowledge of UAV design and operations accumulated during its more than 20-year involvement with UAVs. This includes the range of micro to large scale, long endurance UAVs. This collaborative effort will allow each of the participants to leverage technology, experience, facilities, hardware, skill sets, development, analysis and application.

tracking methods and concepts differ. Misunderstanding of reporting and tracking methods and concepts led to under-reporting of PERSTEMPO. Errors, by a factor of ten, consistently occurred when reporting PERSTEMPO to the Secretary of Defense and the Chairman of the Joint Chiefs of Staff. Another finding was that the current PERSTEMPO is placing heavy demands on the deployable pool, rather than the end strength. PERSTEMPO increases by twelve percent when the deployable pool is placed in the denominator when calculating deployment percentages. The assessment also revealed that there is no tool for the Services to conduct real time assessments of PERSTEMPO. To make these assessments, a BEF model was developed by the RAND Corporation and the Systems Research and Applications (SRA) Corporation and the Joint Staff. This model was designed to produce alternatives for reducing the impact of deployments on military members and to help determine policy regarding the capabilities of the unit deployment and personnel management process.

LAWRENCE LIVERMORE NATIONAL LABORATORY CHAIR PROFESSORSHIP ESTABLISHED

Lawrence Livermore National Laboratory (LLNL) intends to fund a Chair Professorship at NPS to improve closer ties between NPS and LLNL. The Chair will serve as a liaison between the two organizations as well as a focal point for directing research of mutual interest. The LLNL Chair Professor will be able to expose NPS students to expertise that is not readily available on the NPS campus.

Dr. William L. Kruer has been identified as the first chair incumbent. Dr. Kruer is currently Chief Scientist in the Inertial Fusion Theory Division at LLNL. Dr. Kruer has published over 160 articles on basic plasma theory, plasma simulation, laser plasma interactions and inertial fusion. He is the author of a textbook, *The Physics of Laser Plasma Interaction.* Dr. Kruer will be active in teaching, research and thesis advising.

CHAIR PROFESSORSHIP FOR MANPOWER MODELING RENEWED

The U.S. Army Assistant Deputy Chief of Staff for Personnel has recommended the reappointment of Associate Professor **Siriphong Lawphongpanich** of the Department of Operations Research as the Chair incumbent for Manpower Modeling for FY99. The Chair Professorship was established by Memorandum of Understanding in January 1997. Dr. Lawphongpanich has served as the Chair Professor since its inception. His current renewal was based on a review and evaluation of his accomplishment during FY97-98. The Chair's duties include monitoring the review process for work done at NPS for ODCSPER, recruiting Army students to conduct thesis work within ODCSPER, and advising and providing assistance where required to the Strength Management Systems Redesign (SMSR) effort.

NEXT INCUMBENT FOR ONR-SPONSORED CHAIR OF ARCTIC MARINE SCIENCE IDENTIFIED

Dr. Martin O. Jeffries from the Geophysical Institute of the University of Alaska will be the next incumbent in the ONR-sponsored Chair in Arctic Marine Science. Dr. Jeffries is a renowned expert in the properties, distribution and characteristics of Arctic and Antarctic glacial and sea ice. Dr. Jeffries will continue with his research on these topics and interact with NPS Department of Oceanography professors **Robert Bourke**, **Albert Semtner**, **Tim Stanton**, **James Wilson**, **Wieslaw Maslowski**, and **Yuxia Zhang**, who are involved in various polar marine science projects.

The Arctic Marine Science Chair Professorship was established by Memorandum of Understanding between NPS and ONR in 1976. The Chair professor is involved in research, including participation in field programs, teaching and thesis advising, and interaction with the naval establishment.

NAVY CIO VISITS NPS

Dr. Ann Miller, the Navy's Chief Information Officer, visited NPS in August to address the student body at the Superintendent's Guest Lecture on "DoN CIO in the Information Age." The visit provided the opportunity for Dr. Miller to visit with students enrolled in the Space Engineering and Space Operations curricula. **LT Jeff Myers**, USN, **CAPT Darren Powers**, USA, and **LT Charles Seitz**, USN, briefed Dr. Miller on two Space Systems Course Design Projects. A visit to the Microelectronics Research Laboratory (left) revealed some of the important research on radiation effects on VLSI electronics being conducted by Associate Professor **Douglas Fouts** and Assistant Professor **Todd Weatherford**, Department of Electrical and Computer Engineering, and **LT Gary McKerrow**, USN. Dr. Miller visited the Space Systems Engineering Lab where she viewed the facilities and met the engineers responsible for the development of PANSAT, the Petite Amateur Navy Satellite scheduled for launch aboard the Space Shuttle *Discovery* on 29 October. Dr. Miller also toured the FLTSATCOM Laboratory, Spacecraft Dynamics and Control Lab, the Center for Information Systems Security Studies and Research (CISR), and the Software Engineering Lab.

THE TURBOPROPULSION LABORATORY

Professor Raymond P. Shreeve, Director
Associate Professor Garth V. Hobson
Aerospace Engineer Douglas L. Seivwright
Aerospace Technician Rick Still
Department of Aeronautics and Astronautics
Senior Programmer Zafer M. Aktan
Senior Technician Michael D. Aeck
Rolands & Associates, Inc.

The Turbopropulsion Laboratory (TPL) has been active at NPS since 1964 and is committed to the advancement of turbomachinery and air-breathing propulsion. Emphasis has been on the technology of gas turbine engines, and a specific research focus has been concentrated in past years on the aerodynamics of the compressors and turbines required for such engines.

TPL is in a complex of propulsion laboratories that was built on the edge of the Monterey Penninsula Airport for the (then) Department of Aeronautics, in the wake of Sputnik. The complex included low-speed and high-speed laboratories for turbomachinery (Bldgs. 213 & 215 respectively), full-scale jet and turboprop engine test cells (Bldg.216), a rocket laboratory (Bldg.217) and an engine workshop (Bldg.214). The location near the airport was chosen because of the high noise levels inherent in propulsion tests.
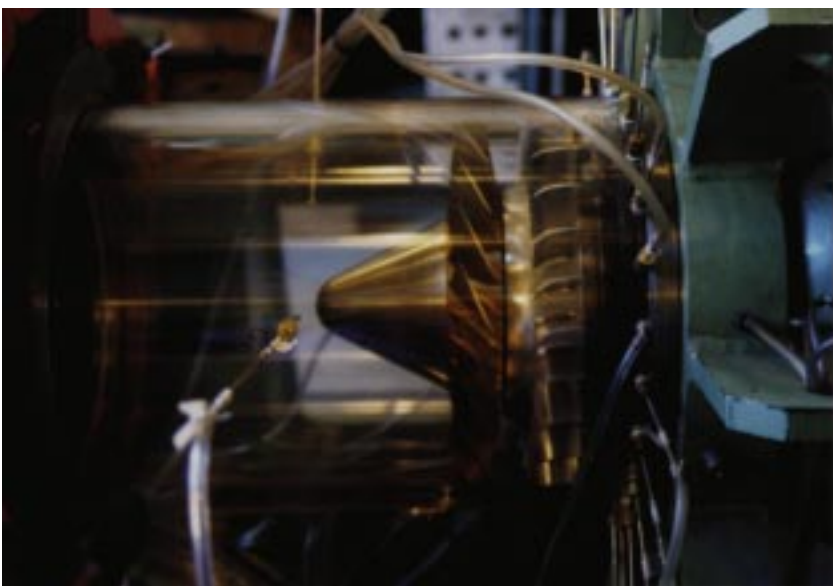
TPL was the brainchild of the late Distinguished Professor M. H. (Mike) Vavra. Building 213 itself is a 'cascade' wind tunnel, and is certainly the largest facility of its type in the world. You must open the many motor-driven windows on all sides of the building before operating the facility. The 500 HP power-supply in the basement of the building can be used to blow or suck air through different panels in the floor. In the Low Speed Cascade Wind Tunnel, the two-dimensional characteristics and the detailed flow field through axial compressor and turbine

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The combination of facilities ... are not to be found anywhere else in the country, or indeed, in the world.

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blading can be determined up to Mach numbers of 0.3 and Reynolds numbers up to two million. Also powered by the basement power supply is a unique Radial Diffuser Test Device. A Low Speed Multistage Axial Research Compressor, with an outer diameter of three feet and driven by its own electric motor, is a third major test facility installed in Bldg. 213.

The High-Speed Laboratory, Bldg. 215, contains a 1200 HP Allis-Chalmers (AC) power supply, three test cells, a spin pit facility, and a control room. It also contains offices and student study spaces were added in 1981. It is the continuous air-supply system in this building, which gives TPL a capability for testing that is unmatched by any other university in this country. Up to 11 pounds per second of air, at up to three atmospheres pressure, can be used to drive a turbine under test in the Turbine Test Rig, or to drive a turbine powering a compressor under test in the Transonic Compressor Rig. The third test cell, also supplied with air from the AC, accommodates a small turbocharger test rig and, at different times, a free-jet for calibrating probes or a ten-inch diameter annular cascade apparatus.

A third compressed-air power supply became available in 1990, when the Aero-Astro Department moved its Gas Dynamics Laboratory

Transonic Compressor - Code Validation Stage
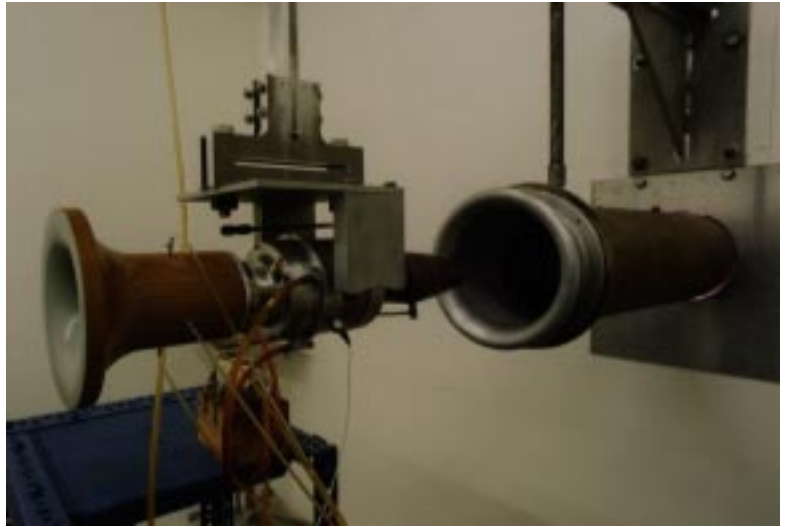
PROPULSION LAB, *continued from page 14*

(GDL) into what had been the turboprop test cell, in Bldg.216. Four large air-tanks provide 8,000 cubic feet of storage at a pressure of 20 atmospheres. Inside the sound-proof, windowless envelope of the GDL, and powered by the building air-supply, are housed a Mach 1.4 to 4.0 supersonic wind tunnel, a Mach 1.4 supersonic fan-blade cascade model, and a supersonic free-jet. In addition, the laboratory contains a micro-jet engine test cell (5-100 pounds of thrust), a three inch diameter double-diaphragm shock tube, and a turbine-driven, rotor test bed for pressure sensitive paint development.

   The combination of facilities described in the above paragraphs, are not to be found anywhere else in the country, or indeed, in the world.

   TPL has had a colorful history. The 60s were a period of great activity as Vavra put each of his new facilities to work. He personally designed all the hardware for the high-speed turbine and compressor rigs, and for the Spin Pit, which was used to test a large turbine rotor for the M1 rocket motor used in the Saturn V launch vehicle. He worked with thesis students and a few visiting investigators who were, most often, from Europe. He was assisted by several technicians, headed an ex-Air Force test pilot, Jim Hammer, who assembled, instrumented and operated the facilities.

   Professor **Raymond Shreeve** joined the TPL in l970. The Department brought in a blue ribbon committee, headed by Hans Mark (Director of the Ames Research Center, and later the Secretary of the Air Force, and now DDR&E) to review TPL. He found "one of the best small academic operations that I have seen." The following year, 1978, Professor Shreeve was appointed Director of the Turbopropulsion Laboratory with a charter "to extend and maintain the role of the Laboratory as a center of excellence in experimental research." Jim Hammer was designated Laboratory Manager. Thus, while it was a complete exception at the time, TPL became the School's first "center," as centers are now defined.

   During 1978-86, TPL fully realized the goals of its charter. The research budget was increased from $43K (from NAVAIR) to $430K in just six years, and sponsorship eventually included projects for ONR, NASA, the Army, DARPA, and Industry. Investigators and staff eventually totaled thirteen, which was about half the size of the rest of

Micro-Gas Turbine Engine Performance Test

the parent Department. During these years the NAVAIR Visiting Research Chair Professor position was filled at TPL by an internationally recognized expert in the field of turbomachinery.

   A number of research "firsts" were achieved by various students, research staff and post-doctoral fellows:
•   A "Dual-Probe, Digital Sampling" measurement technique, using semi-conductor pressure sensors, was developed and used to define the full 3D flow from a transonic rotor operating at 26,000 RPM, and the distribution of shock losses between blades was measured for the first time.
•   The "Centrifugal Diffuser Test Device," a radial flow wind tunnel in which the flow from a centrifugal compressor rotor could be generated on a large scale without moving parts, was built and demonstrated for NASA and the Army.
•   The first air-breathing detonation engine was built and demonstrated in Bldg. 216 by Dr. David Helman. (Detonation engines are currently being investigated and developed in earnest in several places around the country, including the NPS.)
•   A 2D unsteady Godunov CFD code was developed and applied to the port-opening process in a "wave rotor," a rotor with straight passages in which gas-to-gas energy exchange occurs by wave transmission.
•   A "wave rotor project" was initiated at TPL for DARPA.

SUCCESSFUL ANTENNA DEMONSTRATION AT CIRPAS

New communications technology was recently demonstrated at the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS). The objective of the demonstration was to maintain continuous two-way (full duplex) video and command and control data links between a base station and three remote terminals using a single transmit and receive active array antenna at the base station. These objectives were fully accomplished.

The Multifunction Self Aligned Gate Process Active Array Antenna (MSAGAAA) uses tile quads of less than 1 square inch that incorporate 4 radiating elements. The tile includes both active MSAG chips and passive RF and digital components. Each individual element has power and phase controls for beam steering, forming and polarization. The tile quads are assembled into antennas of different sizes and shapes to achieve the desired performance. The demonstrated antenna was designed to receive and transmit 3 full duplex data links simultaneously.

The MSAG process uses a Gallium Arsenide (GaAs) substrate in place of Silicon and a patented process to create multiple types of digital and RF circuitry on a single chip. All required electronics, including phase shifters, digital controls, and power field effect transistors are contained on the chip. The direct current, radio frequency, and phase shifting controls are fed into the chip. The process produces chips with high power efficiencies of up to 50%, a high degree of uniformity, and the ability to run at elevated temperatures. The chips are very durable, with a mean time between failure approaching 1,000,000 hours.

The demonstration used a ground station, a fixed location satellite surrogate (tower), a high mobility multi-purpose wheeled vehicle (HMMWV), and an aircraft. The ground station was located at the CIRPAS facility at the Marina Municipal Airport, 134 feet above sea level. The tower was located about 14 miles away from the ground station on a 1,400-foot peak, while the HMMWV operated about 11 miles away, on a 400-foot ridge. The aircraft flew at 12,500 feet, at ranges of 8 to 10 miles from the ground station. Ku band video and audio links were used between the ground station, tower and aircraft, while X band was used between the ground station and HMMWV.

During the demonstration, commands from the ground station were used to shift video sources on the test platforms between handheld cameras, VCRs, and installed fixed cameras. These source shifts occurred while voice communications and video data transmissions were uninterrupted, showing the simultaneous full duplex send and receive capability of the system. The antenna beam was steered from the control station to track the aircraft and HMMWV.

This technology will have wide ranging applications in the Fleet, as the tile antennas can be used on ships, aircraft, spacecraft, and other vehicles. There is minimal impact to the platform radar cross section as the tiles take up a very small area. Future development of this technology is aimed at supporting over ten simultaneous data links.

ITT Gilfillan Industries and Battlespace, Inc., both of Arlington, Virginia, developed the technology for the Joint Project Office for Cruise Missiles and Unmanned Aerial Vehicles, the Naval Sea Systems Command, and the Naval Surface Warfare Center, Dahlgren Division.

CIRPAS EXPANDS TO CAMP ROBERTS

A new airfield and flight facility to support CIRPAS opened at Camp Roberts, California, in July. The Camp Roberts facility will provide CIRPAS with a base of operations for UAV flight activities. Camp Roberts provides an isolated geographical location with abundant clear airspace, freedom from signal interference, and a clear air corridor to the Pacific Ocean.

The Altus 002 was deployed to Camp Roberts in July in support of an IR surveillance payload demonstration. The 2100 pound approximate 55-foot wingspan UAV, performed flawlessly throughout the deployment.

CENTER FOR AUV RESEARCH UPDATE

The Center for Autonomous Underwater Vehicle (AUV) Research has performed over 30 dives with the *Phoenix* autonomous underwater vehicle and made an equal number of recoveries. The *Phoenix* has established a speed of over three knots for cruising and has performed short survey routes outside the harbor in Monterey Bay. High frequency imaging sonar records have been obtained in preparation for simulated "mine field reconnaissance" tests scheduled in the near future. The Center has been invited to participate in an ocean test in the Gulf of Mexico in November with participants from MIT, Florida Atlantic University, and Woods Hole Oceanographic Institute.

The Center for AUV research began in 1987 with the joining of interested faculty from the Departments of Mechanical Engineering, Computer Science, and Electrical and Computer Engineering. The Center has focused on the development of advanced control methodologies and operational concepts for using AUVs in very shallow water where persistent wave and current action from the seaway make operations difficult. The Center has designed and built two underwater vehicles, *NPS AUV I* and the *Phoenix*, and a third vehicle is currently under construction. Major programs supported by the Center include:

- Sea State Learning and Disturbance Compensation for Shallow Water Mine Warfare
- Fault Detection and Compensation for AUVs
- Small, Low Cost AUV Navigation Using COTS Products and Asynchronous Data Fusion Filters
- Multi-Vehicle Cooperative Approaches to Field Object Detection and Mapping Using Sonar and Video
- Modeling and Simulation of Multiple Low Cost Robotic Vehicles in Minefield Mapping and Target Reconnaissance

SEMINAR SPEAKER SHARES INSIGHTS WITH STUDENTS

Mr. Hugh Montgomery is pictured with students during his guest lecture in NPS Course MN 4305, Seminar in Defense Technology Policy, an upper division elective taught by Associate Professor **Richard Doyle** of the Department of Systems Management. Mr. Montgomery is the Director, Science and Technology Division, Office of the Director of Navy Test and Evaluation and Technology Requirements, Chief of Naval Operation (N911). He is a regular and highly regarded participant in this seminar. The seminar is open to students from all departments and curricula. It takes an interdisciplinary approach to the understanding of the resource and policy issues associated with identifying and procuring the technology necessary for U.S. national security in the post-Cold War era. These issues are particularly acute given the resource constraints under which defense leaders must operate, changes in the defense technology industrial base, and the priority given to advanced technology in achieving military objectives. Mr. Montgomery shared insights with the students on the management of Navy science and technology problems. His comments included descriptions of program trends and problems and the manner in which his office works with the line community, OSD and the congressional defense committees to resolve program issues.

SOFTWARE COMPONENTS FOR AIR DEFENSE PLANNING
Major Arent Arntzen, Royal Norwegian Air Force
Master of Science in Operations Research-September 1998
Advisors: Visiting Assistant Professor Arnold H. Buss and Professor Gordon H Bradley

Modern offensive weapon technologies such as stealth and precision guided munitions have rendered Integrated Air Defense Systems increasingly vulnerable and ineffective. Since air defense is a purely reactive form of warfare, the application of scientific principles to the design and deployment of air defense systems is a major factor in achieving effectiveness. Today's air defense planners face rapidly changing technological developments, both for offensive weapons and for sensors. Understanding the impact of technology on air defense operations must be done continually and at an increasing pace. The combination of dwindling defense resources and rapid technological developments makes the need for analysis more critical. Yet with current software architectures, even the analysis activity may by prohibitively costly for small nations.

Major Arntzen was the 1998 recipient of the MORS/Tisdale Award. The Military Operations Research Society (MORS) sponsors the MORS/Tisdale Graduate Research Award for outstanding thesis work in the NPS Department of Operations Research. The award recognizes high quality research of immediate or near-term value to the Department of Defense.

Stealth effectively reduces the performance of radar, but does not have the same impact on passive systems. Sensors have been the most important and vulnerable part of air defense systems through the history of air warfare. Research into passive sensors has been encouraging, but before passive sensor systems are produced, procured and deployed, analysis and planning must be conducted to quantify potential benefit and determine feasible system configurations. As this type of analysis encompasses extremely complex systems behavior, developing reusable and flexible models becomes important.

Of all modeling tools available, system simulation is perhaps the only one capable of capturing the behavior of Integrated Air Defense Systems. Unfortunately, building and using a simulation model is an expensive, slow, and cumbersome activity. Since model abstractions must ultimately be turned into computer code, the productivity of a simulation modeling depends heavily on effective software engineering and programming.

Reuse is the key to increasing effectiveness in simulation modeling. Component Software is a technology that allows reuse of both model abstractions and implementations. Furthermore, this technology makes the simulation model scalable, allowing the analyst to start with a simple model and build towards higher complexity and fidelity. Building models using software components thus allows the analyst to develop a model in a series of stepwise refinements. Progressing in small steps using components, the analyst can derive the simplest possible model for the task at hand, minimizing the effort that goes into parts of the model that ultimately would not be used, thus increasing productivity.

This thesis uses Java, a new and powerful object-oriented programming language, to develop a prototype software component architecture and component library for building simulation models for air defense. Sensor and airborne weapon simulation components are demonstrated and used in an exploratory analysis of the impact of a network of Infrared Search and Track (IRST) sensors. A practical scenario comprising a modern medium range Surface-to-Air System (MSAM) is laid out as the basis for the simulation models. The data gathered from the models indicate that IRST systems could be valuable in the near future.

High tempo seems to be a dominating feature of theories of modern warfare. If simulation models are to be used for planning purposes under such circumstances the cycle time from one model to the next must be very short. Current methods fall far short of this requirement. In addition to providing model configuration flexibility and scalability, the component architecture supports reuse and makes data collection very simple. This thesis shows how these combined features can reduce modeling cycle-time dramatically in the context of air defense planning. Also, and of great interest to small nations, the high level of abstraction and reusability achieved by the component architecture may allow the functions of domain expert and simulation analyst to be combined in one individual.

A TASK ANALYSIS OF UNDERWAY REPLENISHMENT FOR VIRTUAL ENVIRONMENT SHIP-HANDLING SIMULATION SCENARIO DEVELOPMENT
LT Steven D. Norris, United States Navy
Master of Science in Computer Science-September 1998
Advisors: Assistant Professor Rudolph Darken and Senior Lecturer John S. Falby, Department of Computer Science, and Assistant Professor Dylan Schmorrow, Department of Operations Research

While developing a Virtual Reality (VR) Ship-Handling simulator for the Surface Warfare Officer School (SWOS) in Newport, RI, researchers at the Naval Air Warfare Center Training Systems Division (NAWCTSD) in Orlando, Florida, discovered a need for a task analysis of a Conning Officer during and Underway Replenishment (UNREP). The purpose of this task analysis was to document the tasks the Conning Officer performs and cues used to accomplish these tasks. The task analysis would ensure that the correct tasks and cues would be modeled in the VR UNREP scenario.

   The approach taken was to survey cognitive task analysis models to find a notation that would document the tasks performed by a bridge team during an UNREP. The Goals, Operators, Methods, Selection Rules (GOMS) model was selected. A GOMS-like model was used to represent the sequential aspects of the UNREP task, while a tale was developed to capture the parallelism of the tasks. The UNREP task analysis was then reviewed by qualified Surface Warfare Officers to validate its accuracy.

   The result of this effort was a validated task analysis model of a Conning Officer during an UNREP. This model was provided to NAWCTSD in support of their future efforts in the development of a VR UNREP Ship-handling simulator scenario.

DESIGN OF A MICROELECTRONIC CONTROLLER WITH A MIL-STD-1553 BUS INTERFACE FOR THE TACTILE SITUATION AWARENESS SYSTEM
LT Brian L. Luke, United States Navy
Electrical Engineer-September 1998
Advisors: Associate Professor Douglas Fouts and Assistant Professor Randy Wight, Department of Electrical and Computer Engineering

Spatial Disorientation (SD) is a tri-service aviation problem that costs DoD more than $300 million annually in destroyed aircraft and is the primary cause of pilot-related mishaps in the Navy and the Air Force. As one solution to the SD problem, the Naval Aerospace Medical Research Laboratory has developed the Tactile Situation Awareness System (TSAS). The primary objective of TSAS is to enhance pilot performance and reduce SD-related aircrew/aircraft losses by providing continuous non-visual information using the normally underutilized sensory channel of touch. Using vibrotactile simulators, TSAS applies information taken from the aircraft's instruments to the pilot's torso. The current implementation of the TSAS is a research system that is not compatible with the crowded cockpit of modern aircraft. This thesis presents a design of a microelectronic controller for TSAS compatible with tactical environments. This new system, called the Tactor Interface Microcontroller System (TIMS), incorporates the functionality of the research TSAS into a palm-sized microcontroller system and enables TSAS to communicate directly to the computerized sensory and weapons systems in combat aircraft such as the Navy F/A-18. TIMS brings the TSAS prototype out of the research stage and puts this exciting technology into the hands of the warfighter.

A PROCESS SIMULATION DESIGN TO ASSESS PROMISING TECHNOLOGIES RELEVANT TO F/A-18 AIRCREW TARGET RECOGNITION
Major Eric V. Bryant, U.S. Marine Corps
Masters of Science in Information Technology Management - September 1998
Advisors: Assistant Professor William K. Krebs, Department of Operations Research, and Lecturer Terrance C. Brady, Information Systems Academic Group

F/A-18 aircrew visual target recognition during air-to-ground

weapons employment is accomplished by the integration of sensors, systems, and information processing by the aircrew. The aircrew's ability to rapidly obtain target recognition from the cockpit display of the target scene is critical to accurate weapons delivery. Using system engineering principles, a process simulation design was devised consistent with DOD acquisition reform regulations that simulates how aircrew perform visual search and target recognition in attack aircraft, and it provides

THE NEW NATO AND COLLECTIVE SECURITY
Professor David Yost
Department of National Security Affairs

While the Allies remain committed to collective defense, they have increasingly endowed NATO with new roles as an instrument of collective security in the Euro-Atlantic region. Elements of Partnership for Peace (PFP), the May 1997 NATO-Russia Founding Act, the stabilization commitment in post war Bosnia and other activities, have raised new challenges for NATO's cohesion and effectiveness: how to give practical content to its vision of a peaceful political order in Europe, how to handle the hypothetical issue of eventual Russian membership in the Alliance, what meaning to attribute to vague "security is indivisible" declarations and the Article 4-like security consultation commitments offered to PFP members, and how to maintain collective defense in good order while assuring collective security duties. These issues are addressed in Dr. Yost's forthcoming book, *NATO Transformed: The Alliance's New Roles in International Security.*

CONCEPTS FOR C4ISR AND INFORMATION SUPERIORITY IN HUMANITARIAN ASSISTANCE/DISASTER RELIEF (HA/DR) OPERATIONS IN THE 21st CENTURY
Professor Michael G. Sovereign
Command, Control and Communications (C3) Academic Group

This project supported an effort by the joint headquarters of the Commander in Chief, Pacific Command, to develop an information superiority concept of operations for the lower end of the operational spectrum using the capabilities of Joint Vision 2010, beginning with Humanitarian Assistance/Disaster Relief (HA/DR) operations. It included a workshop and experimentation with the principal investigator on-scene at USCINCPAC, Honolulu, Hawaii, for one year.

At a conference of over 100 experts in C3 and HA/DR operations on the topic of improved procedures and technologies for HA/DR operations, the Virtual Information Center (VIC) concept for obtaining information from non-traditional sources (Internet, modeling and simulation, international business community, non-governmental organizations and commercial remote sensors) was developed, and initial arrangements were made for an experiment to test the concept. The concept was further defined in the conference proceedings issued by the OSD's Command and Control Research Program (CCRP). The VIC experiment was conducted in April 1998 with the assistance of the Joint C4ISR Battle Center in Suffolk, Virginia. The experiment included the CINC role player at USCINCPAC headquarters, the CJTF role player in Suffolk, an ambassador at the U.S. Army War College, and several other players in Washington D.C. locations. Connectivity was by Internet, desk-top VTC and SIPRNET plus phones. The scenario was a simulated hurricane in the Philippine Islands with requests for aid from U.S. authorities. Several days before the hurricane and several days after were simulated during the week of the experiment. The Consequence Assessment Tool Set (CATS) model from the Defense Special Weapons Agency was used to project the hurricane and the damage sustained. Other models were used for planning medical support and for estimating the cost of the operation. The CINC and CJTF issued Requests for Information (RFI) to the VIC through a controlled web-site available to all the participants. The VIC then assigned the RFI to the various sources including the Center for Excellence in Disaster Management and Humanitarian Assistance (COE) at Trippler Army Hospital in Honolulu. A synthesis of the information obtained was then prepared by the VIC and posted to the web-site so that everyone could see the state of information. The CINC and CJTF role players found this process very satisfactory in bringing additional information to their attention in a timely manner. Admiral Joe Prueher, the USPACOM CINC, visited the experiment and specified that the system be instituted to provide information to him and his staff.

CENTER FOR CIVIL MILITARY RELATIONS PARTNERSHIP WINS GRANT

The U.S. Agency for International Development (USAID) has awarded a $4M, three-year grant to the Naval Postgraduate School's Center for Civil-Military Relations (CCMR) and its project partner, the National Democratic Institute in Washington, D.C. CCMR already conducts programs around the world to help new democracies strengthen civilian control over their militaries, and build effective defense policymaking and budgeting systems. In September 1998 alone, CCMR taught seminars for flag officers, legislators and senior civilian officials in five countries: Argentina, Senegal, Indonesia, Georgia, and Mongolia. The Center also conducts seminars and conferences in-residence at NPS. The faculty for CCMR is comprised of NPS faculty members and adjunct faculty from around the world.

The USAID grant will enable CCMR to launch a number of research initiatives. Center faculty members will write over a dozen comparative case studies of civil-military relations in new democracies. These studies will not only broaden knowledge in the field but also be of direct, practical value to foreign educational institutions and policymakers. The USAID grant will also fund the establishment of an information clearinghouse to disseminate CCMR's research to foreign legislators, non-government organizations, universities and U.S. embassy personnel around the globe. In addition, CCMR will use the grant to help civic organizations in Latin America, Asia and Africa tackle issues in civil-military relations.

A number of major research universities competed against the CCMR/National Democratic Institute partnership to win the USAID grant. The fact that CCMR received the award not only reflects the past accomplishments of the Center, and the reputation for excellence its staff and faculty have established, but also the contribution that CCMR can make to U.S. policy objectives in the future.

Wayne Hughes, Senior Lecturer in the Department of Operations Research, was awarded the Hugh G. Nott Prize from the Naval War College for the 1997 publishing year. This award is made in memory of CAPT Hugh G. Nott, USN, who made major academic and research contributions over a period of ten years at the Naval War College.

The article, "Naval Maneuver Warfare," appeared in the Summer 1997 issue of the *Naval War College Review*. Describing the longstanding advantages of mobility at sea for operational maneuvers, Professor Hughes emphasized the Navy-Marine Corps team contribution while suggesting the Navy support of future ground operations in littoral waters will be more demanding tactically.

In a congratulatory letter from RADM J.R. Stark, Professor Hughes' article was described as, "an incisive, thorough, and provocative assessment of a topic of vital and growing interest to the naval service." The letter further stated that, "The members of our selection committee were impressed by the analytical power and enduring value of your work."

Professor Hughes points out with pleasure that his thesis student **LT Mark Beddoes**, USN, won second prize. LT Beddoes' article appeared in the Autumn 1997 issue and was titled, "Logistical Implications of Operational Maneuvers from the Sea." An abridgement of LT Beddoes thesis, the article was an analysis of the logistical implications of Marine "ship-to-objective maneuvers."

INFORMATION WARFARE WORKSHOP

The Naval Postgraduate School hosted the Fourth Annual 1998 Information Warfare (IW) Workshop in August 1998. The classified three-day workshop, sponsored by the Department of Energy (DoE) focused on U.S. infrastructure assurance. Approximately 80 representatives of various intelligence activities of the federal government, military services, and contractor elements were in attendance. NPS students and staff, with the requisite security clearances, were invited to participate. The concept of Information Warfare or Information Operations (IW/IO) is a national security issue that has grown in increasing importance within the United States defense establishment in recent years. DoD forums such as this workshop seek to master the concept and to define future collection strategies that assure the United States' information dominance in the 21st Century. NPS provided an unbiased, unrestrained environment for all participants to freely discuss issues concerning their organizations and to stay current with the requirements and complexities affecting IW/IO collection and analysis. The DoE plans to continue sponsoring future IW workshops at NPS in the future.

Representatives from the Department of Energy, Department of Transportation, National Security Agency, Central Intelligence Agency, Federal Bureau of Investigation, the National Reconnaissance Office, the Pentagon and numerous national laboratories were in attendance. Most of these attendees have responsibilities in IW, involving the passive and/or active exploitation (e.g., collection, processing, analysis and reporting) of foreign information and the denial of American and allied information to potential adversaries. Others are involved in U.S. critical infrastructure protection that includes identifying national policy implementation strategies to protect these systems from physical and/or cyber threats.

The workshop was divided into two distinct phases. In Phase I, selected participants provided briefings designed to update attendees on their organizations' respective roles and recent accomplishments in various areas of offensive and defensive IW/IO. Phase II provided an intellectual exercise in which participants examined cyberwar/netwar scenarios. The group was divided into three teams, each assigned a specific netwar war-game scenario, which included three game moves. Following each game move, the team leaders provided a brief presentation to the entire

MILITARY OPERATIONS RESEARCH SOCIETY SYMPOSIUM (MORSS)

The 66th MORS Symposium was held at the Naval Postgraduate School on 23-25 June 1998. The theme was "Preparing for Military Operations Research in the 21st Century." Nearly 1,100 military operations research analysts, users of military operations research, allied disciplines and decision-makers attended. The keynote address was delivered by Dr. William J. Perry, former Secretary of Defense. About 800 papers were presented in three Special Sessions, seven Composite Groups, 32 Working Groups and a Poster Session. Seven tutorials on such diverse subjects as "Genetic Algorithms: Application and Theory," and "Blackhawk Down: An Account of the 1993 Mogadishu Firefight," were also presented. Two of the tutorials were half-day sessions presented the day before the start of the Symposium.

During the opening plenary session, several analysts were recognized for their outstanding work and contributions to the community. The David Rist Prize for the best paper submitted in response to a call for papers in 1997 was awarded to Dr. Paul H. Deitz and Michael W. Starks, Army Research Laboratory, Survivability/Lethality Analysis Directorate, for their paper, "The Generation, Use, and Misuse of 'PKs' in Vulnerability/Lethality Analysis." The Richard Barchi Prize for the best paper presented at the 66th MORSS was presented to Arthur Brooks of The RAND Graduate School, and Bart Bennett and Steve Bankes of the RAND Corporation for their paper, "An Application of Exploratory Analysis: The Weapon Mix Problem."

POLAR ICE PREDICTION SYSTEM WORKSHOP

Under the leadership of Professors **Albert Semtner** and **Robert Bourke**, Department of Oceanography, NPS hosted an ONR-sponsored workshop to devise a science plan for developing the next generation Polar Ice Prediction System (PIPS 3.0) Forecast Model. About 30 scientists convened at Fleet Numerical Meteorology and Oceanography Center in July to lay the groundwork for this five-year effort to improve the Navy's ability to accurately forecast the presence, thickness, and motion of sea ice in northern hemisphere waters.

PATENTS ISSUED AND FILED

Former NPS Associate Professor Ranjan Mukherjee and Electronics Technician **Tom Christian** of the Department of Mechanical Engineering were issued a U.S. Patent for their invention titled, "Actuation System for the Control of Multiple Shape Memory Alloy Elements," (U.S. Patent Nr. 5,763,979).   An actuation system for the control of multiple shape memory alloy elements is achieved by arranging the shape memory actuators into a matrix comprised of rows and columns which results in approximately a fifty percent reduction in the number of electrical connecting wires. This method of actuation provides the scope for resistance measurements of the shape memory alloy actuators and, therefore, feedback control of the actuators can be accomplished without additional wires.

Dr. Mukherjee along with Research Assistant Professor **Gangbing Song,** Department of Aeronautics and Astronautics, filed a patent for their invention titled, "Articulated Manipulator for Minimally Invasive Surgery (AMMIS)," (Navy Case No. 77535). The U.S. Patent Office has notified NPS that this invention will issue as a patent in the near future.

IW WORKSHOP, *continued from page 22*

group, which highlighted their team's strategy and results for their assigned scenario.

The value of the IW Workshop lies in the collegial exchange of ideas and concepts to assure greater understanding of the scope and nature of national critical infrastructure vulnerabilities and threats. It also serves as a forum to investigate U.S. policy and legal issues raised by efforts to protect these vital infrastructures and assure computer security. The DoD consensus is that IW/IO will dominate 21st Century conflict and that, properly conceived, information operations can be inexpensive, highly effective, and executed by all levels and in all places. In the final analysis, information superiority over an adversary will decide conflicts long before conventional warfare is necessary, so the U.S. intelligence community must be prepared and ready to take appropriate counter-measures! The NPS plays a significant role in providing IW education for future collectors and decision-makers. By hosting workshops such as this, NPS provides an unrestrained venue for all, including students and staff, to stay current with the issues and complexities involving IW collection and analysis.

NPS AWARDED TWO DoD SBIR TOPICS

NPS recently learned that two of the three candidate topics submitted for consideration for the Small Business Innovative Research (SBIR) Program will be included in the 99.1 DoD SBIR solicitation scheduled for release on 1 December 1998. The SBIR Program focuses on science and technology that enhances DoD's capabilities. The program is directed at funding dual-use technologies, anticipating that the products of each SBIR R&D effort will be useful to both the military and the private sector.

Included in the 99.1 solicitation will be Department of Electrical and Computer Engineering Assistant Professor **Todd Weatherford**'s topic on "Radiation Hardened Wide Bandgap High Power DC-DC Converters for Space Applications." The objective is to combine recent research efforts in wide bandgap materials and devices in order to develop DC-DC converters for space-based application requiring greater that 1kW loads. Radiation tests on the prototype will provide benchmark data on wide bandgap technologies required for space propulsion, space radar and other power applications.

Research Assistant Professor **Wolfgang Baer**, Department of Computer Science, suggested a topic titled, "Intrinsic Earth Surface Material Classifier." The objective is to provide a system to process sensor data into permanent earth surface physical descriptor codes from which reliable and accurate sensor signatures can be generated. The availability of intrinsic earth surface material classification systems will support remote sensing data reduction, GIS systems, and Earth Resource Repositories. Both the establishment of service bureaus and the direct sales of software tools could be realized from this technology.

Professors Weatherford and Baer will review resulting proposals from the solicitation, recommend award of at least one Phase I and possibly a Phase II contract per topic, monitor their technical performance, and plan follow-on R&D as required. SBIR Phase I awards are limited to $70k over six months with a $30k option over three months. SBIR Phase II awards are limited to $600k over two years typically with a $150k 6-month "bridge" option. SBIRs usually result in an end product about three years after release of the initial solicitation.

AERONAUTICS AND ASTRONAUTICS

C.M. Dohrin, L. Fottner, and **M.F. Platzer**, "Experimental and Numerical Investigation of Flapping Wing Propulsion and its Application for Boundary Layer Control," International Gas Turbine & Aeroengine Congress, ASME Paper 98-IGTI-46, Stockholm, Sweden, 2-5 June 1998.

J.A Ekaterinaris and **M.F. Platzer**, "Computational Prediction of Airfoil Dynamic Stall," *Progress in Aerospace Sciences*, Vol. 33, pp. 759-846, 1998.

K.D. Jones, C.M. Dohring, and **M.F. Platzer**, "Experimental and Computational Investigation of the Knoller-Betz Effect," *AIAA Journal*, Vol. 36, No. 7, pp. 1240-1246, 1998.

K.D. Jones and **M.F. Platzer**, "On the Prediction of Dynamic Stall Onset on Airfoils in Low-Speed Flow," *Proceedings of the International Symposium on Unsteady Aerodynamics and Aeroelasticity of Turbomachines*, pp. 797-812, 1998.

J.C.S. Lai and **M.F. Platzer**, "The Characteristics of a Plunging Airfoil at Zero Free-Stream Velocity," ASME Fluids Engineering Summer Meeting, ASME Paper FEDSM 98-4946, Washington, D.C., 22-25 June 1998.

M.F. Platzer was elected to a two-year term as Chair of the Structures and Dynamics Committee of the International Gas Turbine Institute of the American Society of Mechanical Engineers.

M.F. Platzer, J.C.S. Lai, and C.M. Dohring, "Flow Separation Control by Means of Flapping Foils," *Proceedings of the International Symposium on Seawater Drag Reduction*, pp. 471-478, Newport, RI, 22-23 July 1998.

W. Sanz and **M.F. Platzer**, "Nu- merical Investigation of the Stall Onset Behavior of the GA(W)-1 Airfoil," *Computers & Fluids*, Vol. 27, Nos. 5-6, pp. 681-687, 1998.

I.H. Tuncer and **M.F. Platzer**, "Potential Flow Solutions with Wakes Over an Ogive Cylinder," *Journal of Spacecraft and Rockets*, Vol. 35, No. 3, May-June 1998.

I.H. Tuncer and **M.F. Platzer**, "Computational Study of Subsonic Flow Over a Delta Canard-Wing-Body Figuration," *Journal of Aircraft*, Vol. 35, No. 4, pp. 554-560, July-August 1998.

I.H. Tuncer, R. Waltz, and **M.F. Platzer**, "A Computational Study on the Dynamic Stall of a Flapping Airfoil," AIAA Paper 98-2519, 16th AIAA Applied Aerodynamics Conference, Albuquerque, NM, 15-18 June 1988.

E.R. Wood, "Simulation of Helicopter Dynamic Mechanical Instability by MAPLE Based Nonlinear Lagrangian Derivation," Paper AIAA-98-2005, 39th Structures, Structural Dynamics, and Materials Conference, Long Beach, CA.

E.R. Wood, **LCDR R. King**, and LT C. Robinson, "Full Nonlinear Simulation of Coupled Rotor/Fuselage Response Using Symbolically Derived Equations of Motion," 54th Annual Forum of the American Helicopter Society, Washington, D.C., 20-22 May 1998.

Prof. **E. R. Wood** and a group of other selected speakers from the AIAA VISTOL Aircraft Committee jointly presented a 4-day short course on problems and solutions associated with giving an aircraft vertical and short takeoff and landing performance. More than fifty students attended the course offered at Patuxent River, Maryland, for the benefit of Naval Air Systems Command and Naval Air Warfare Center engineers. The course focused on the forthcoming joint services procurement for a Joint Strike Fighter.

COMPUTER SCIENCE

C. Irivine, "Meeting Security Requirements for Global Commerce: Can Education Help?" National Colloquium for INFOSEC Education, Harrisonburg, VA, 18-20 June 1998.

J.B. Michael, "Automating Bus Docking to Improve Transit Service," *Intellimotion*, Vol. 7, No. 2, pp. 1-3, 15, 1998. The electronic version of the article is available at: http://www.path.berkeley.edu/PATH/Intellimotion/

J.B. Michael, "Computer Security Issues Related to Using COTS Software," IEEE International Workshops on Critical-Functions Considerations for ISO/IEC 15288—System Life Cycle Processes: Safety, Off-the-Shelf Items, Quality Management and Engineering Principles, Monterey, CA, 10-11 August 1998.

G. Xie, "SAAM: A Network Management System for the Next Generation Internet," *Proceedings of 2nd NASA NREN QoS Workshop*, August 1998.

G. Xie, "SAAM: A Network Management System for the Next Generation Internet," 2nd NASA NREN QoS Workshop, NASA Ames Research Center, CA, August 1998.

Prof. **M. Zyda** has been appointed to the National Research Council Committee on Advanced Engineering Environments. The National Research Council (NRC) is starting work on a study of technologies associated with what NASA terms "advanced engi-

neering environments": integrated, distributed, virtual environments for designing, testing, and prototyping aerospace systems. Such environments would link designers, manufacturers, customers, suppliers, and consultants involved in creating and operating products such as spacecraft and aircraft.

ELECTRICAL AND COMPUTER ENGINEERING

O. Duzenli and **M. Fargues**, "Wavelet-Based Feature Extraction Methods for Classification Applications," 1998 IEEE Signal Processing Workshop on Statistical Signal and Array Processing, Portland, OR, 13-16 September 1998.

E. Threet and **M. Fargues**, "Economic Evaluation of Voice Recognition for the Clinician's Desktop at the Naval Hospital Roosevelt Road (NHRR)," *Journal of Military Medicine.*

R. Janaswamy, "A Curvilinear Coordinate Based Split-Step Parabolic Equation Method for Propagation Predictions Over Terrain," *IEEE Transactions on Antennas and Propagation*, Vol. 46, No. 7, pp. 1089-197, July 1998.

R. Janaswamy and J.B. Andersen, "Path Loss Predictions in Urban Areas Sprawling Over Irregular Terrain," *Proceedings of the 9th IEEE International Symposium on Personal, Indoor and Mobile Radio Conference*, No. D4 (a4), pp. 534-538, Boston, MA, 8-11 September 1998.

D.C. Jenn, **P.E. Pace**, N.T. Hatziathanasiou, and **R. Vitale**, "Symmetrical Number System Phase-Sampled Antenna Architectures," IEEE Antennas and Propagation

Society International Symposium, Atlanta, GA, June 1998.

D.C. Jenn, **P.E. Pace**, T.N. Hatziathanasiou, and **R. Vitale**, "High Resolution Wideband Direction Finding Arrays Based on Optimum Symmetrical Number System Encoding," *IEEE Electronics Letters*, Vol. 34, pp. 1062-1064, June 1998.

P.E. Pace, D. Styer, and I.A. Akin, "A Folding ADC Employing a Robust Symmetrical Number System with Gray-Code Properties," *Proceedings of the IEEE International Symposium on Circuits and Systems*, Monterey, CA, June 1998.

P.E. Pace, D. Styer, and W.P. Ringer, "Optimum SNS-to-Binary Conversion Algorithm and FPGA Realization," *Proceedings of the IEEE International Symposium on Circuits and Systems*, Monterey, CA, June 1998.

P.E. Pace and G.D. Burton, "Automatic Extraction of EWIRDB Parameters from Threat Missile Simulators," 66th Military Operations Research Society Symposium, Monterey, CA, June 1998.

P.E. Pace and M.D. Nash, "A Novel Independent Sensor Fusion Algorithm for Time-Space-Position Information in Captive-Carry Missile Simulator Experiments," 66th Military Operations Research Society Symposium, Monterey, CA, June 1998.

P.E. Pace and **LT G.D. Burton** installed the latest version of the Automatic Extraction of Threat Simulator Critical Parameters (AETSCP Version 3.0) software at the Tactical Electronic Warfare Division, Naval Research Laboratory, Washington, D.C. on 28 August 1998. This software is used by the Navy's ASCM Simulator Validation Working Group to extract missile EWIRDB param-

eters from anechoic chamber characterization data.

P.E. Pace and **LT M.D. Nash** delivered the first version of the Centralized TSPI Software Architecture to the Tactical Electronic Warfare Division, Naval Research Laboratory, Washington, D.C. on 28 August 1998. This software is used onboard the NRL P-3 research aircraft to perform absolute targeting during the captive-carry HIL missile simulator experiments.

P.E. Pace and Mr. S-Y Yeo delivered a Field Programmable Gate Array (FPGA) image synthesizer prototype to the Tactical Electronic Warfare Division, Naval Research Laboratory, Washington, D.C. on 3 September 1998. The hardware prototype is used for counter-targeting high range resolution radar (e.g., SAR, ISAR).

R.J. Pieper and A.D. Kraus, "Performance Analysis of Double Stack Cold Plates Covering All Conditions of Asymmetric Loading," *Journal of Electronic Packaging*, Vol. 130, pp. 296-301, September 1998.

X. Yun and N. Sarkar, "Unified Formulation of Robotic Systems with Holonomic and Nonholonomic Constraints," *IEEE Transactions on Robotics and Automation*, Vol. 14, No. 4, pp. 640-650, August 1998.

X. Yun, G.C. Hernandez, E.R. Bachmann, **R.B. McGhee**, and **A.J. Healey**, "An Integrated GPS/INS Navigation System for Small AUVs Using an Asynchronous Kalman Filter," IEEE Conference on Autonomous Underwater Vehicle (AUV'98), Cambridge, MA, 20-21 August 1998.

INFORMATION SYSTEMS ACADEMIC GROUP

H.K. Bhargava, R. Krishnan, and

P. Peila, "On Formalizing the Semantics of Typed Modeling Languages: An Analysis of Ascend," *INFORMS Journal on Computing*, 10:2, pp. 189-208, Spring 1998.

H.K. Bhargava, R. Krishnan, and S.O. Kimbrough, "On Planning to Plan: Metaplanning Concepts in the Context of Management Science Modeling," INFORMS Conference on Information Systems and Technology, Montreal, Canada, April 1998.

M. Ceruti and **M. Kamel**, "Heuristics-Based Algorithm for Identifying and Resolving Semantic Heterogeneity in Command and Control Federated Database Systems," *Proceedings of the 1998 IEEE Knowledge and Data Engineering Exchange Workshop, KDEX'98*, Taipeh, Taiwan, Republic of China, November 1998.

D. Dolk, "Modeling in the Data Warehouse Era," AMAP: IFIP WG7.6-IIASA Workshop on Advances in Modeling, Paradigms, Methods and Applications, Vienna, Austria, 21-23 September 1998.

D. Dolk, "Metrics-Based Decision Support," 12th JISR-IIASA Workshop on Methodologies and Tools for Complex System Modeling and Integrated Policy Assessment, Vienna, Austria, 24-26 September 1998.

M. Kamel, "Knowledge Acquisition," *Encyclopedia of Electrical and Electronics Engineering*, John G. Webster, ed., February 1999.

M. Kamel, "Migrating Legacy Systems and Databases," *Proceedings of the Federal Database Colloquium DBASE'98*, San Diego, CA, September 1998.

M. Kamel conducted a seminar for the United Nations World Intellectual Property Organization (WIPO) on Information Technology and Intellectual Property, Cairo, Egypt, June 1998.

M. Kamel, "The Internet from Hypertext to Distributed Objects," Internet Conference CAINET'98, March 1998.

N.F. Schneidewind, "State of the Art Presentation 2: Software Reliability Modeling for Client Server Systems," Fourth IEEE International Conference on Engineering of Complex Computer Systems, Monterey, CA, 13 August 1998.

N.F. Schneidewind, "Have We Forgotten a Few Things in the Euphoria Over COTS?" International Workshops on Critical-Functions Considerations for ISO/IEC 15288 – System Life Cycle Processes: Panel on Off-the Shelf Items, Session 6B, Monterey, CA, 11 August 1998.

N.F. Schneidewind, "How to Evaluate Legacy System Maintenance," *IEEE Software*, Vol. 15, No 4, pp. 34-42, July/August 1998.

N.F. Schneidewind and Chrstof Ebert, "Preserve or Redesign Legacy Systems?" *IEEE Software*, Vol. 15, No. 4, pp. 14-17, July-August 1998.

N.F. Schneidewind, "How I Watched in Pain as IBM Outsmarted UNIVAC," Robert L. glass, ed., *The Software Practitioner*, pp.5-7, Vol. 8, No. 3-4, May-August 1998,

N.F. Schneidewind, "*IEEE Standard for a Software Quality Metrics Methodology: Revision*," Celia Modell, ed., IEEE /Standards Office, July 1998.

The Steering Committee of the International Conference on Software Maintenance appointed Prof. **N. Schneidewind** as General Chair of the International Conference on Software Maintenance 2000 to be held in Silicon Valley.

Prof. **N. Schneidewind** has been named the Publicity Chair of the 1998 International Conference on Software Maintenance.

MECHANICAL ENGINEERING

A.G. Fox, R. L. Johnson, and J.F. Dill, "The Effect of Water Temperature on the Underwater Wet Weldability of ASTM A516 Grade 70 Steel," *Proceedings of OMAF 98*, p. 2262, July 1998.

A. Gopinath and E.H. Trinh, "Steady Streaming from a Non-Compact Sphere," 16th International Congress on Acoustics and 135th Meeting Acoustical Society of America, Seattle, WA, June 1998.

A. Gopinath, "Thermoacoustic Effects at a Solid-Fluid Boundary," 4th Microgravity Fluid Physics and Transport Phenomena Conference, Cleveland, OH, August 1998.

A.J. Healey, E.P. An, **D.B. Marco**, and **S.M. Smith**, "Multi Sensor Asynchronous Extended Kalman Filtering for AUV Navigation," *IEEE Journal of Oceanic Engineering*.

A.J. Healey, "Analytical Redundancy and Fuzzy Inference in AUV Fault Detection and Compensation," *Proceedings of Oceanology 1998*, Brighton, 11-14 March 1998. http://web.nps.navy.mil/~me/healey/papers/oceanology98.pdf

A.J. Healey, "Model Based Residual Generation for AUV Fault Detection," *Proceedings of the IEEE Conference on Underwater Technology, UT-98*, April 1998.

A.J. Healey, "Progress in Fault Detection and Wave Motion Compensation," VPI/MURI Program Progress Review, Blacksburg, VA, 13-14 April 1998.

A.J. Healey, "Autonomous

Vehicles in Mine Countermeasures," Mine Countermeasure Conference, Monterey, CA, 6-9 April 1998.

D.B. Marco, **A.J. Healey**, "System ID," *Proceedings of the International Advanced Robotics Program*, February 1998.

J.S. Riedel, **A.J. Healey**, "Model Based Predictive Control of AUVs for Station Keeping in a Shallow Water Wave Environment," *Proceedings of the International Advanced Robotics Program IARP 98*, February 1998.

J. Riedel, **A.J. Healey**, "Wave," *Proceedings of the International Advanced Robotics Program*, February 1998.

E.S.K. Menon, **M. Saunders**, and **I. Dutta**, "Interface Characterization of Metallized CVD Diamond," *Proceedings of Microscopy and Microanalysis 1998*, Springer-Verlag, p. 778, July 1998.

E.S.K. Menon and **M. Saunders**, "Elemental Distributions in Au-Metallized CVDD," *Proceedings of the 14the International Congress in Electron Microscopy*, Vol. 3, p. 461.

E.S.K. Menon, **A.G. Fox**, and G. Spanos, "Carbon in Retained Austenite," *Proceedings of the 14th International Congress in Electron Microscopy*, Vol. 2, p. 211.

M. Saunders, **E.S.K. Menon**, D.J. Chisholm, and **A.G. Fox**, "Extracting Chemical Information from Energy Dispersive X-Ray Spectra by Multivariate Statistical Analysis (MSA)," *Proceedings of Microscopy and Microanalysis 1998*, p. 204, July 1998.

M. Saunders, **E.S.K. Menon**, and **A.G. Fox**, "Determination of Interface Composition Variations by the Application of Multivariate Statistical

Analysis to Energy Dispersive X-Ray Spectra and Electron Energy Loss Spectra," Scandem 98 Conference, Helsinki Finland, July 1998.

M. Saunders, **E.S.K. Menon**, and **A.G. Fox**, "Using Statistical Information to Identify and Map Interface Reaction Phases from EDS Spectra," *Proceedings of the 14th International Congress in Electron Microscopy*, Vol. 3, p. 597.

M. Saunders, **E.S.K. Menon**, and **A.G. Fox**, "Quantitative Convergent Beam Electron Diffraction (CBED) Studies of Metals and Alloys," *Proceedings of the 14th International Congress in Electron Microscopy*, Vol. 3, p. 779.

M. Saunders, **E.S.K. Menon**, **R.Y. Hashimoto**, and **A.G. Fox**, "Interface EELS Analysis: Comparison of Spatial Difference and Multivariate Statistical Analysis (MSA) Techniques," *Proceedings of the 14th International Congress in Electron Microscopy*, Vol. 2, p. 571.

T. Sarpkaya and **LCDR C. Merrill**, "Spray Generation from Wall-Bounded High-Speed Jets," International Conference on Multiphase Flows, Lyon, France, 7-12 June 1998.

T. Sarpkaya, "Resistance in Unsteady Flow-Search for a Physics Based Model," Naval Hydrodynamics Symposium, Washington, D.C., 9-14 August 1998.

T. Sarpkaya and **LCDR C. Merrill**, "Drop Formation on High-Speed Jets Over Curved Walls," Naval Hydrodynamics Symposium, Washington, D.C., 9-14 August 1998.

T. Sarpkaya and **F. Novak**, "Turbulent Vortex Breakdown: Experiments in Tubes at High Reynolds Numbers," *Dynamics of Slender Vortices*, (E. Kreuse and A.

Gerstens, eds.), pp. 287-297, July 1998.

T. Sarpkaya, "Decay of Wake Vortices of Large Aircraft," *Journal of the American Institute of Aeronautics and Astronautics*, Vol. 37, No. 9, pp. 1671-1679, September 1998.

Dist. Prof. **T. Sarpkaya** has been appointed a member of the Atmospheric Flight Mechanics Committee of the American Institute of Aeronautics and Astronautics.

T. Sarpkaya, **"**Drag and Inertial Components of Unsteady Flow Over Perforated Bodies," Fluids Engineering Conference of ASME, Washington, D.C., 22-26 June 1998.

METEOROLOGY

R.L. Elsberry, "Track Forecast Guidance Improvements for Early Warnings of Tropical Storms," Early Warning Conference 98, Potsdam, Germany.

Prof. **P. Durkee** was selected as Principal Investigator and Co-investigator on two out of 21 proposals recently funded as part of the NASA Radiative Impact of Aerosols on the Earth's Climate Program. Prof. **Durkee** will serve on the science team that will produce the first global aerosol climatology of the earth.

C. Collins, **T. Murphree**, et al, *The State of the California Current, 1997-1998: Transition to El Nino Conditions*, California Cooperative Oceanic Fisheries Investigations Reports, 39.

T. Murphree served as an instructor for the Maury Project, a national program in physical oceanography education for pre-college teachers, conducted by the American Meteorological Society and the U.S. Naval

Academy, Annapolis, Maryland, 19-31 July 1998.

T. Murphree and M. Miller, *Watching Weather*, Henry Holt, 154 pp, July 1998.

T. Murphree, "The Evolution and Impacts of the 1997-El Nino," Pacific Fisheries Environmental Laboratory/ NOAA, Pacific Grove, CA, 15 July 1998.

NATIONAL SECURITY AFFAIRS

G. Robinson, "Defensive Democratization in Jordan," *International Journal of Middle East Studies*, Vol. 30, No. 3, August 1998.

D. Yost, "The New NATO and Collective Security," *Survival*, Summer 1998.

OCEANOGRAPHY

W.J. Cai and **P.C. Chu**, "A Thermal Oscillation Under a Restorative Forcing," *Quarterly Journal of the Royal Meteorological Society*, 124, pp. 793-809, 1998.

P.C. Chu and **C.W. Fan**, "Improvement of Estuarine and Coastal Modeling Using High-Order Difference Schemes, Estuarine and Coastal Modeling," *American Society of Civil Engineering*, 2, pp. 28-34, 1998.

P.C. Chu, **S.H. Lu**, and **Y.C. Chen**, "Wind-Driven South China Sea Deep Basin Warm-Core/Cool-Core Eddies," *Journal of Oceanography*, 1998.

P.C. Chu, **C.W. Fan**, C.J. Lozano, and J. Kerling, "An AXBT Survey of the South China Sea," *Journal of Geophysical Research*, 1998.

P.C. Chu, **Q.Q. Wang**, and **R.H. Bourke**, "A Geometric Model for Beaufort/Chukchi Sea Thermohaline Structure," *Journal of Atmospheric*

and Oceanic Technology, 1998.

P.C. Chu and E. Gottshall, "METOC Support for Mine Countermeasure," 66th Military Operations Research Society Symposium, Monterey, CA, 10-12 June 1998.

P.C. Chu, "Joint Simulation System (JSIMS) Maritime METOC Component," Maritime Integrated Training Architecture Symposium, Stennis Space Center, MS, 3-4 September 1998.

P.C. Chu, **S.H. Lu**, and **Y.C. Chen**, "Second Kind Predictability in Climate Models," Rossby-100 International Symposium, Stockholm, Sweden, 8-12 June 1998.

E.L. Gallagher, E. Elgar, and **E.B. Thornton**, "Megaripple Migration in a Natural Surf Zone," *Nature*, Vol. 384, 9 July 1998.

E.L. Gallagher, E. Elgar, and **E.B. Thornton**, "Megaripple Migration in a Natural Surf Zone," 26th International Conference on Coastal Engineering, Copenhagen, Denmark, 22-26 June 1998,

L.N. Ly and P. Luong, "A New Advance in Coastal Ocean Modeling: Application of the Grid Generation Technique," *High Performance Computing Contributions to DoD Mission Success 1998*, p.113, 1998,

L.N. Ly and P. Luong, "A Numerial Simulation of Summer Circulation for Monterey Bay, Coastal Hydrodynamics Modeling," *Hydraulic Engineering Software VII*, W.R. Blain, ed., pp. 225-235, 1998.

L.N. Ly and P. Luong, "A Ocean Modeling System Development and an Application to the South China Sea Simulation," *Hydrometeorology Topics of the South China Sea*, H.V. Phan, ed., pp. 81-100, 1998.

L.N. Ly and P. Luong, "On a Numerical Simulation of Summer

Circulation for Monterey Bay," Seventh International Conference, HYDROSOFT-98, Como, Italy, September 1998.

L.N. Ly and P. Luong, "Winter Circulation of the South China Sea Using a Coastal Ocean System with Breaking Wave Effects and Numerical Grids," AGU Western Pacific Geophysics Meeting, Taipeh, Taiwan, July 1998.

L.N. Ly and P. Luong, "NAM Ocean Modeling System Development and An Application to the South China Sea," South China Sea International Workshop, HoChiMinh-City, Vietnam, June 1998.

L.N. Ly and P. Luong, "A Three Dimensional Modeling for the Monterey Bay Circulation," Poster at the National Ocean Conference, Monterey, CA, June 1998.

E.B. Thornton, F. Wiersma, and **T.P. Stanton**, "Vertical Profiles of Longshore Currents During SandyDuck," 26th International Conference on Coastal Engineering, Copenhagen, Denmark, 22-26 June 1998.

The Oceanography Department has become a full member in the Consortium of Ocean Research and Education (CORE), the national organization representing all the major institutions involved in ocean education and research efforts. Drawing upon the interest generated by the recent National Ocean Conference, NPS has joined with University of California, Santa Cruz, Moss Landing Marine Laboratory, California State University, Monterey Bay, and University of California, Santa Barbara to form a regional consortium and NPS' membership in CORE will be as part

of the Monterey Bay Crescent Ocean Research Consortium.

OPERATIONS RESEARCH

S. Buttrey, "Nearest-Neighbor Classification with Categorical Variables," *Journal of Computational Statistics and Data Analysis*, August 1998.

S. Buttrey, "Three-Based Methods for Forecasting Retention," 66th Military Operations Research Society Symposium, Monterey, CA, 23 June 1998.

R. McDaniel, D. Scribner, **W.K. Krebs**, P. Warren, N. Ockman, and **J. McCarley**, "Image Fusion for Tactical Applications," *Proceedings of the SPIE 43rd Annual Symposium on Optical Science, Engineering, and Instrumentation*, 3436, 1-11.

PHYSICS

J.H. Luscombe, "Simplified Recursive Algorithm for Wigner 3j- and 6j-Symbols," *Physical Review E*, Vol. 57, pp. 7274-77, 1998.

SYSTEMS MANAGEMENT

W. Bowman and **S. Mehay**, "Career Advancement of Minority Officers in the U.S. Navy," Western Economic Association Annual Meetings, Lake Tahoe, NV, June 1998.

M. Cook, P. Hogan, and **S. Mehay**, "Enlistment Supply at the Local Level," Western Economic Association Annual Meetings, Lake Tahoe, NV, June 1998.

G. Hildebrandt and Sergei Pechersky, "The Use of Award Fee Contracts in Defense Procurement," Western Economics Association Meetings, Lake Tahoe, NV, June 1998.

G. Hildebrandt and R.E. Franck, Jr., "China's Make Versus Buy Decision," Western Economics Association Meetings, Lake Tahoe, NV, June 1998.

G. Hildebrandt and Raymond E. Franck, Jr., "From Lanchester Models to Cost Analysis," 66th Military Operations Research Society Symposium, Monterey, CA, 23-25 June 1998.

G. Hildebrandt and Manbing Sze, "Aircraft O&S Cost Estimating Relations Using Cross Section and Time Series Data," 66th Military Operations Research Society Symposium, Monterey, CA, 23-25 June 1998.

G. Hildebrandt, "What is the Difference Between Economics and Operations Research?" 66th Military Operations Research Society Symposium, Monterey, CA, 23-25 June 1998.

S.P. Hocevar, "Deciding to Adapt Organizational Architecture: Facilitators and Inhibitors to Change," *Proceedings of the 1998 Command and Control Research and Technology Symposium*, pp. 78-95, June 1998.

S.P. Hocevar, **W.G. Kemple**, and R. Benson, "Translating Model-Based Findings to an Operational Arena: Interpretations from Research Participant-Experts," *Proceedings of the 1998 Command and Control Research and Technology Symposium*, pp. 54-65, June 1998.

L. Jones, "Reinvention Labs as Change Agents in the U.S. Department of Defense," Academy of Management Conference, San Diego, CA, 11 August 1998.

K. Kang, **D. Eaton**, K. Mooney, and G. Sanchez, "Cycle Time Reduction to Improve Naval Aviation Readiness," 66th Military Operations Research Society Symposium, Monterey, CA, June 1998.

M.J. Lebas and **K.J. Euske**, "A Conceptual and Operational Delineation of Performance," *Performance Measurement-Theory and Practice, Volume I, Proceedings of the Interna-*

We are living in the Information Age, but information turns out to be so expensive that it can displace other systems in a limited Defense budget. What is the right balance? NPS student, LtCol Yost, has found a way to answer the question for prolonged air-to-ground battles, as in Desert Storm. In such battles, targets occasionally appear to be functional when they have actually been destroyed, and appearances can also be deceiving in the other direction. Battle Data Assessment can reveal the true status of such targets, but the required sensors are expensive and therefore in short supply. How should such battles be fought, and how do results depend on available information and firepower assets? The question is answered using a unique combination of Linear Programming and Partially Observable Markov Decision Processes, two previously uncombined Operations Research techniques. Using the decomposition methodology that LtCol Yost has developed, realistically scaled problems are solvable in about one minute. The U.S. Air Force has already expressed interest in using the resulting software to investigate tradeoffs between information and firepower.

LtCol Yost received his Doctor of Philosophy in Operations Research from NPS in September 1998. Professor Alan R. Washburn of the Department of Operations Research was his Dissertation Supervisor.

tional Conference on Performance Measurement-Theory and Practice at the Judge Institute of Management Studies, University of Cambridge, Andy D. Neely and Daniel B. Waggoner, (eds.), pp. 333-339, July 1998.

S. Mehay and P.F. Hogan, "The Effect of Separation Bonuses on Voluntary Quits: Evidence from the Military's Downsizing," *Southern Economic Journal*, 65(1), pp. 127-139, 1998.

M. Nissen and A. Mehra, "Redesigning Software Procurement Through Intelligent Agents," *Proceedings of the 1998 AAAI Conference, Workshop on Using AI for Knowledge Management and Business Process Reengineering*, pp. 1-10, 1998.

M. Nissen and A. Mehra, "Case Study: Intelligent Software Supply Chain Agents Using ADE," *Proceedings 1998 AAAI Conference, Workshop on Software Tools for Developing Agents*, pp. 53-62, 1998.

Prof. **N. Roberts** organized a Showcase Symposium, "Peace Matters Most," for the Academy of Management Meetings, San Diego, CA, 9 August 1998.

N. Roberts, "Stakeholder Collaboration in Crisis Countries," Academy of Management Meetings, San Diego, CA, 9 August 1998.

N. Roberts, "Strategic Planning in the Federal Government: Lacking a Good Fit with the Political Context," Academy of Management Meetings, San Diego, CA, 9 August 1998.

Prof. **N. Roberts** will be taking a leave of absence to work with the United Nations Staff College in Turino, Italy during the 1998 fall term. She will be serving as an outsider reviewer to assist the Staff College in its structural and functional review of programs, planning and organization. The goal of the effort is system-wide strategic and operational performance improvement in the areas of planning and coordinated action, inside and outside the UN, especially those activities concerning peace operations.

D. Shade, **J.F. Raffensperger**, **K. Kang**, and G. Pearman, "Optimizing the Privatization of Military Family Housing," 66th Military Operations Research Society Symposium, Monterey, CA, June 1998.

J. Suchan, "The Effect of High-Impact Writing on Decision Making Within a Public Sector Bureaucracy," *Journal of Business Communication*, Vol. 35, No. 3, pp. 299-327, Summer 1998.

G. Thomas facilitated two workshops for the Trident Training Facility at the Bangor Submarine Base: "Understanding Racism" and "Understanding Sexism." These two-day workshops are part of a four workshop series on Managing Diversity in the Military.

K.W. Thomas, **G.F. Thomas**, and **S.P. Hocevar**, "Values Implicit in the Word 'Empowerment': Historical Analysis and an Interview Study in a U.S. Organization," *Proceedings of the 6th International Conference on Work Values and Behavior*, July 1998.

K. W. Thomas, **G.F. Thomas**, and **S.P. Hocevar**, "Values Implicit in the Word 'Empowerment': Historical Analysis and an Interview Study in a U.S. Organization," 6th International Conference on Work Values and Behavior, Istanbul, Turkey, July 1998.

K.W. Thomas, "A Three-Dimensional Model of Leadership Values from the U.S. Army Reserve: Qualitative Evidence and Theoretical Remifications," 6th International Conference on Work Values and Behavior, Istanbul, Turkey, July 1988.

UNDERSEA WARFARE ACADEMIC GROUP

J. Breemer, "Sea Power in the Next Century," *Sea Power in the Next Century: Maritime Operations in Asia-Pacific Beyond 2000, Australian Defence Studies Centre*, Jack McCaffrie and Alan Hinge, eds.,

INSTITUTE FOR DEFENSE EDUCATION AND ANALYSIS

The American Psychological Association has recently elected Research Professor **Pat-Anthony Federico** to Fellow status. This required his work having national impact on the field of psychology beyond a local, state, or regional level. He was nominated by the Division of Applied Experimental and Engineering Psychology.

P-A. Federico, "Comparing Training Regimes for a High-Intensity Complex Task," American Psychological Association, San Francisco, CA, August 1998.

DEFENSE RESOURCES MANAGEMENT INSTITUTE

Prof**. J. Blandin** has been asked to serve on the National Security Studies Senior Advisor Board at the Maxwell School of Citizenship and Public Affairs, Syracuse University.

G. Grosheck and **D. Rose**, "Uncertainty and the Design of DoD Contracts," Western Economic Association Meetings, Lake Tahoe, NV, June 1998.

R. Looney and **P.C. Frederiksen**, "Rail Track Expansion in Developing Countries in the 1980s," *Transportation Research-E* (Logistics and Transportation Review), Vol. 34, No. 2, 1998.

ARCHITECTURE, *continued from page 3*

graphs and overlaying them on maps; and facilities for dynamically loading and running algorithms on the König graph objects. MAJ Jackson developed the König component as part of his PhD research. König contains a toolkit of methods to quickly construct graph and network algorithms. It also contains methods to load, display, and manipulate graphs and networks. A fourth part is currently not represented in the system, but perhaps best embodies the distillation of the lessons we have learned so far. This part consists of a standard for components and is implemented in the Modkit package. MAJ Arntzen is the primary author of this standard; it was developed with much intense discussion and experimentation by the group. MAJ Arntzen's thesis used Modkit to create rapid prototypes of Discrete-Event Simulation models of Integrated Air Defense Systems (IADS) that utilized both active and passive sensors with the goal of evaluating the contribution of the passive sensors. He was recently awarded the MORS/Tisdale prize for the best military Operations Research master's thesis (see Student Research, page 18).
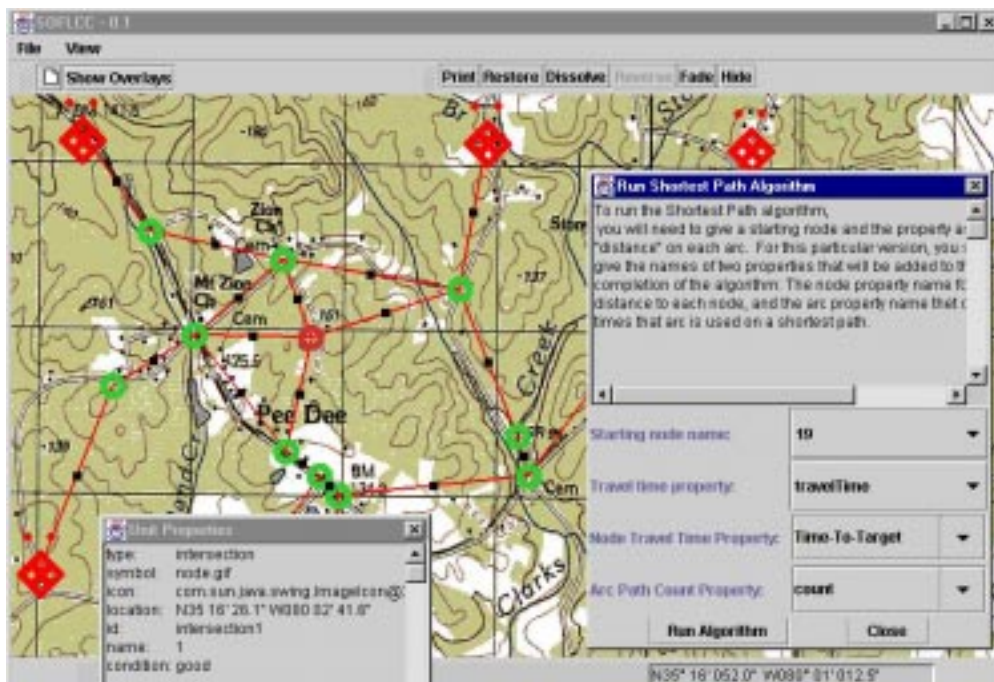
The Modkit component standard represents a substantial advance over current component technologies such as Java Beans. It supports dynamic, recursive composition and effectively enables the users of conforming components to rapidly assemble extremely complex models from simple building blocks. Modkit's component standard will form the conceptual basis for the next-generation system, which has an anticipated release six months hence.

Applications of the Research

The research approach has been to augment our conceptual work by developing several Advanced Concept Technology Demonstrations (ACTDs) at NPS based on our architecture in order to demonstrate and validate our approach. This empirical approach has allowed us to rapidly test or fast prototype our ideas. It has also allowed us to use these working prototype systems to demonstrate the design and to show the capabilities that emerging information technology can bring to military planning. Our first demonstration project is the thesis work of **LT Sean Moriarty**, USN, (MS in OR September 1997) who was in the Operational Logistics curriculum. The system is a prototype advanced planning system for interdiction and restoration of logistics lines of communication. The system can load a map locally or download one from anywhere on the Internet. The user constructs a distribution network, i.e., transportation, power, communications, etc., by using the mouse to specify a network of nodes and arcs over the map. Properties can be specified for the nodes and arcs (for example, cost, capacity). The system can invoke an algorithm to determine an optimal allocation of forces to arcs in order to disconnect the nodes that are the sources of goods from designation nodes. In his thesis, LT Moriarty described three possible scenarios for his system: interdiction of supply routes (as was done in Viet Nam and more recently in the interdiction of drugs), the protection of a distribution network from attack, and an Operations Other the War (OOTW) mission to optimally apply resources to restore water after a natural

Special Operations Forces Planning and Execution Prototype—computing the time for enemy units to engage Navy Seals who are attacking a radar site.

ARCHITECTURE*, continued from page 31*

disaster. Because the system is written in Java, it executes without modification on a wide variety of computing devices and environments. The project demonstrated that using easily available technology, a military planning system that downloaded resources from a network could be quickly constructed.

   Immediately after the completion of the first system, the basic architecture group assessed the strengths and weaknesses of the system and after three months of research and design began work on the second generation, which resulted in a system to do dynamic planning and execution for Special Operations. This system includes an improved mapping component, the graph component developed by MAJ Jackson, and several algorithms developed by MAJ Arnsten using his Modkit component standard. The system was constructed to address a Special Operations scenario developed by **CPT Allan Bilyeu**, USA (MS in OR, June 1998) that is described in his thesis. The Special Operations Forces (SOF) scenario involves the attack on a radar site in Bosnia by a Navy Seal team operating in the Adriatic Sea. Air Force Special Forces operating out of Italy transport the Seals to the site. Army Special Forces working with coalition forces and NATO troops support the Seals on the ground. This map-based system supports downloading from a network various resources such as maps, satellite images, overlays of forces, roads, etc., and algorithms for use in developing plans in real time to support the mission. The loosely coupled components architecture allows these resources to be loaded as needed and to be incorporated dynamically into the executing system. The platform independence that Java provides is very critical to SOF because their planning involves units from different services, other government agencies, coalition forces, and international agencies spread around the world. It is unlikely they will be using identical computers or operating systems. Our system for planning and execution provides a common operating picture and similar functionality to units that are geographically dispersed and are using different hardware and software.

    Planning does not cease with the onset of a mission's execution, but must continue as the mission unfolds. A planning system must therefore be capable of immediately reacting to any unanticipated events. As the mission proceeds, operators rather than planners become increasingly involved in the planning/replanning process. Thus,

systems for planning and execution must provide seamless support of a common operating picture for both operators and planners. In the operations environment, the available computing devices are smaller (cellular phones, palmtops, etc.) and have fewer resources than the computing platforms available to the planners. A common operating picture must be maintained even as the active participants in the system change. Our architecture and system software was designed from the beginning to support capabilities across the widest possible range of computing devices from super-computers to the emerging small, lightweight battlespace devices. To that end, the kernel system was designed with the smallest possible computational footprint (currently less than 1 MB). By taking advantage of the relative large bandwidth from satellite to ground unit and the capability of our planning system to load resources as needed and when needed, small computing devices have sufficient capabilities to present an operational picture and to support local computation to do continuous replanning.

   The dynamic capabilities of the system are best shown by considering how algorithms are located, loaded, and executed. The user selects a graph embedded in an overlay and then selects an algorithm (for example, shortest path or max flow) to execute on it. Any algorithm may be selected to run on any graph at the user's discretion. Since Java has dynamic loading, algorithms need not be loaded until they are needed. A class containing an algorithm can be loaded from the local machine or over a network. Once a class is selected, the system loads it using its name (a string). Utilizing a Java capability called reflection, the names of the algorithms in the class are discovered and presented to the planner. After the planner selects an algorithm, the system uses reflection on the algorithm to determine the parameters needed to execute it. For example, in a shortest path algorithm, the parameters are a source node and an arc property for the length. The system presents the planner with a short description of the algorithm and drop-down menus to select which of the nodes is the source and which arc property should be used for the length (there could be several choices, for example, length via road or length via air). The system then executes the algorithm and places the solution in the graph in the form of new or modified properties. For example, in a shortest path algorithm, the user may decide that each node should have a property called "Time-To-Target" that would represent the length of the shortest path from the node to the target. When the

ARCHITECTURE*, continued from page 32*

algorithm is executed, that property is added to each node. Since the algorithm is loaded dynamically, it need not be known at compile time or even at the onset of the planning session. In an extreme example, an analyst at a remote location could be writing an algorithm while the planning is going on and, as soon as the algorithm is completed, it can be located, loaded into the planning system, and executed on a graph model. Although the general capabilities for dynamic behavior are built into Java, it should be noted that some specific capabilities are achieved only by using the loosely coupled components architecture that we have developed over the past year.

We have taken the prototype SOF system for planning and execution from design to the development of a working system in less than seven months; thus we have been able to give live demonstrations of the capabilities of a system based on our loosely coupled components architecture. This has allowed us to effectively present the work to high level personnel who may not have the technical background to understand the details of our design. Furthermore, these rapid cycles have allowed us to apply lessons learned from each application of the system to the design of the next generation.

Another recent application constructed with our architecture and components is the Coordinated Inland Area Search and Rescue (SAR) System (COINSS), developed as part of the thesis of **LT Timothy Castle**, USCG (MS in OR, September 1998). COINSS is a system to support the execution of searches for missing people in the continental United States. It advances the state-of-the-art by constructing a component that accounts for the movement of the target after the search begins, by integrating the calculations with a map and graphical user interface, and by implementing the software so that it can be executed without modification on a wide variety of computers. COINSS is a set of computational algorithms that compute a probability distribution of the location of the target over the search region. As the search proceeds, the distribution is updated to account for the movement of the target. The movement is calculated by applying a Markov process to a movement vector of velocities that depends on the type of target (for example, a child, as opposed to an adult hiker). The system can include elevation data; the system currently uses Digital Terrain Elevation Data Level 1 (DTED1) from the National Imagery and Mapping Agency (NIMA).

Computer Science Research Assistant Professor **Wolfgang Baer** assisted us in accessing this information. The elevation data is used to compute the slope of the ground, which is then used to modify the movement of the target. The search coordinator assigns areas to various search teams. After each unsuccessful search of an area, the probability distribution is updated using Bayes theorem. COINSS was developed as a separate component, which was then integrated with the map, overlay, graph and algorithm components described above in the SOF application. The map component displays a map and provides latitude and longitude information; the overlay and graph components allow the search region and the search assignments to be input by mouse clicks, and the algorithms component makes the connection between the visual display and COINSS. The probability distribution is displayed over the map in shades of red to indicate the probabilities. The search coordinator (and any one monitoring the search) can see at a glance the changing search probabilities as the target moves and as search teams report back negative results. The integration of COINSS with the other components was done quickly because components in the loosely coupled design know very little about each other. The map layer displays images without knowing if they are maps, satellite pictures, graphs or probability distributions. To the system kernel, COINSS is just an application that has algorithms to invoke and an overlay to display. A significant benefit of the design is the interchangeability of components. Although the COINSS application was designed to find lost people in the United States, it can be invoked from the SOF application to find a downed pilot in Bosnia or track a fleeing war criminal.

Another application that uses the components is the thesis research of **LT Scott Schwartz**, USN (MS in OR, September 1998) that constructs a system to solve graph partition problems. The focus of his thesis is a problem from the Defense Information Systems Agency (DISA) to determine the optimal sequence to upgrade a communications network that has more than 200 nodes. The problem is modeled as the partition of a graph into a given number of subgraphs. Because there are no effective algorithms to construct an optimal solution, the system allows an analyst to construct a good (but not necessarily optimal) solution by dynamically specifying a sequence of heuristic algorithms to be applied to the problem. Because there are too many nodes and arcs to be displayed effectively, this

ARCHITECTURE*, continued from page 33*

application is not map-based. However, the system employs the graph component to construct the heuristics and the algorithm component to dynamically load and execute the algorithms.

Presentations and Research Sponsors
In the past year the authors have given eleven presentations of the results in classified settings at the National Security Agency (NSA) and Headquarters, United States Special Operations Command (USSOCOM), and in unclassified presentations at professional meetings in the United States and abroad. We have also given a number of demonstrations to NPS visitors and in Washington.

The demonstration systems have been of particular interest to our research sponsors because they have provided early proof that advanced systems for planning and execution can be built using Java and that these systems can access resources over a network of heterogeneous computer assets. We have shown that we can dynamically locate, access and execute algorithms, and thus build "thin clients" that load programs if and when needed. This is particularly important for the emerging small, lightweight battlespace computing devices. The loosely coupled design shows how new components can be added quickly to existing systems. The research has been of interest to the general operations research community because it demonstrates that traditional analysis tools that have been used off-line can be integrated into real time systems.

The basic research on the architecture is supported by a 6.1 grant from the Air Force Office of Scientific Research (AFOSR) to Bradley and Buss. The AFOSR program is funded under an initiative based on the Air Force's New Worlds Vista study which "identified those technologies that will guarantee the air and space superiority of the United States in the 21st century." The research on graph and network algorithms is supported by a 6.1 grant from the Office of Naval Research (ONR) to Bradley, and to Professors **Jerry Brown** and **Kevin Wood**. The participation of MAJ Jackson is supported by the U.S. Army TRADOC Analysis Center (TRAC) - Monterey. NPS' Institute for Joint Warfare Analysis (IJWA) has provided support to LTC Shaw to develop the Special Operations planning tools and scenarios. The IJWA funds have been matched by the USSOCOM. USSOCOM has supported the development of realistic contemporary and future joint military planning scenarios by allowing students to spend

Graduation September 1998: Professor Gordon Bradley, LT Timothy Castle, LT Scott Schwartz, Major Leroy Jackson, Major Arent Arntzen, LTC Charles Shaw, Visiting Assistant Professor Arnold Buss

six weeks at their headquarters at MacDill AFB before they begin their thesis research.

The authors are advising USSOCOM on the development of their Mission Planning, Analysis, Rehearsal and Execution (MPARE) System. MPARE is the management and oversight process that will guide the integration and use of constructive simulations and computer based operational tools to enhance combat capability of special operations forces. GEN Schoomaker, CinC USSOCOM, has designated MPARE the command's "flagship" system. We are members of the Requirements Integration Program Team (RIPT) with responsibilities to contribute to the development of the Concept of Operations (CONOP) and Operational Requirements Documents (ORD) which are currently being written. We are also responsible to provide information on technological trends in C4I and possible "leap ahead" technologies.

Ongoing Research
We have begun the development of the third generation of demonstration systems based on our loosely coupled architecture. Our rapid design/development cycles match those of the commercial technologies that we use. In high technology, COTS development times are measured in so-called "internet time," with systems being developed and deployed in months rather than the years that is typical of many DoD software projects. While our architecture and user interface remain stable, it is easy to extend our systems

UNDERWATER EXPLOSION, *continued from page 5*

The predicted gross bodily motion of the ATD dummy is also in reasonably good agreement with the images captured from the video of the test event. Basic phasing of the motion agrees well with the video although the arm motion is significantly different. One source of differing motion is the seat back. The angle that the seat back makes with the seat pan is increased after the first recoiling of the dummy into the seat back. However, the seat back was not modeled as being able to rotate in the simulations.

Overall, the agreement between the predicted and recorded motions and accelerations was considered to be quite good and sufficient to demonstrate the validity of the model.
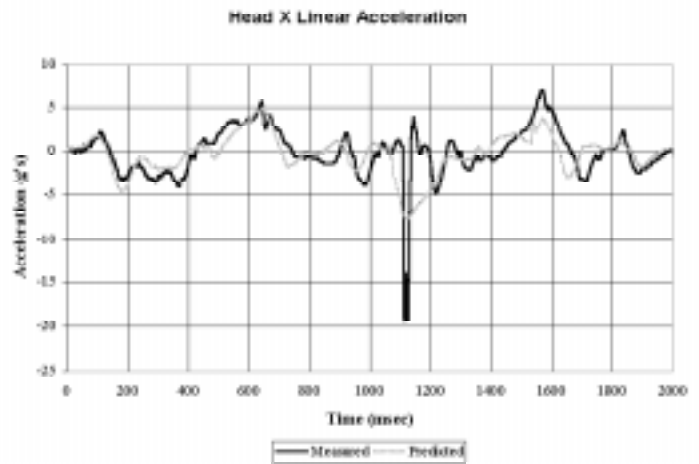
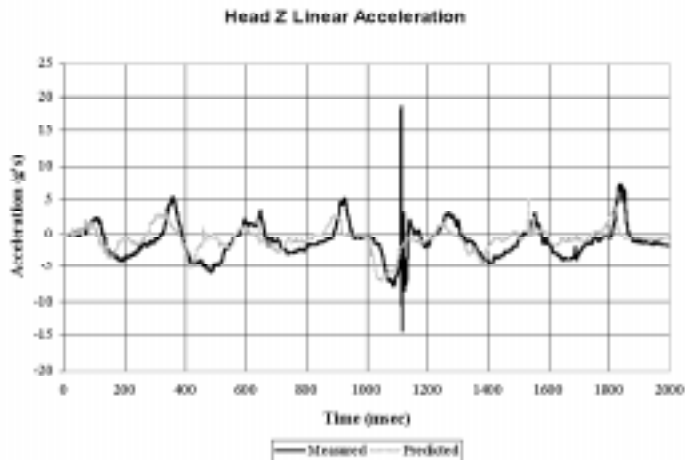*Figure 2. Comparison of head x accelerations*
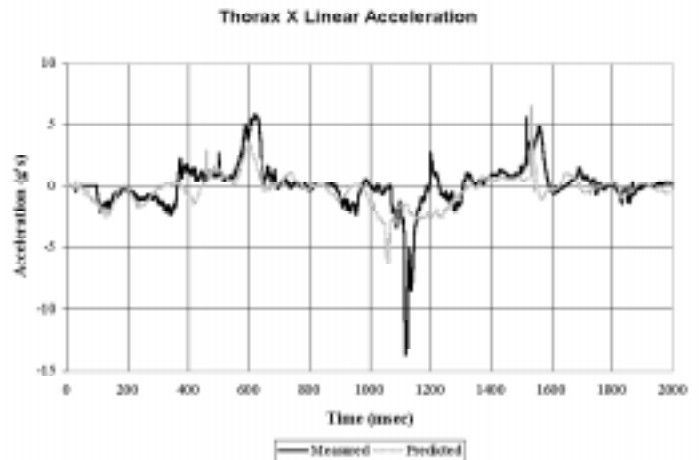
Figure 3. Comparison of head z accelerations

Figure 4. Comparison of chest X accelerations

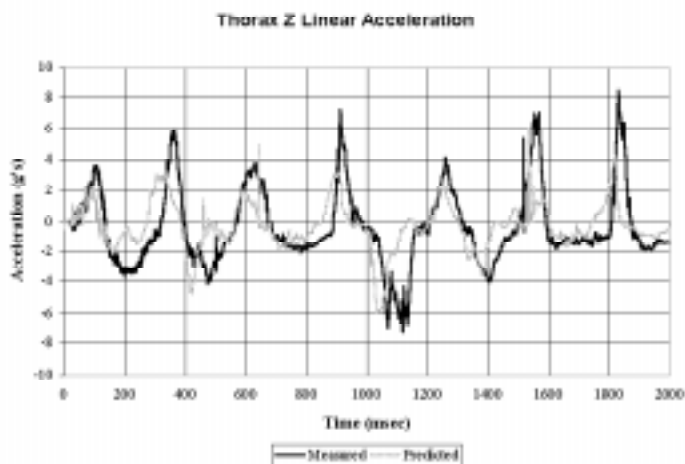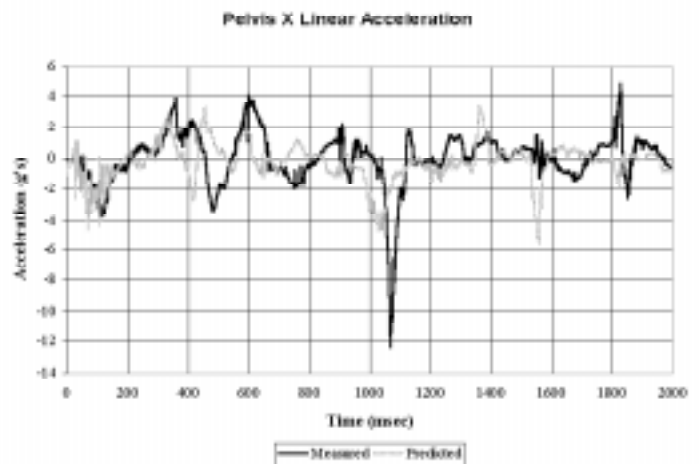*Figure 5. Comparison of Z chest accelerations*

Figure 6. Comparison of pelvis X accelerations

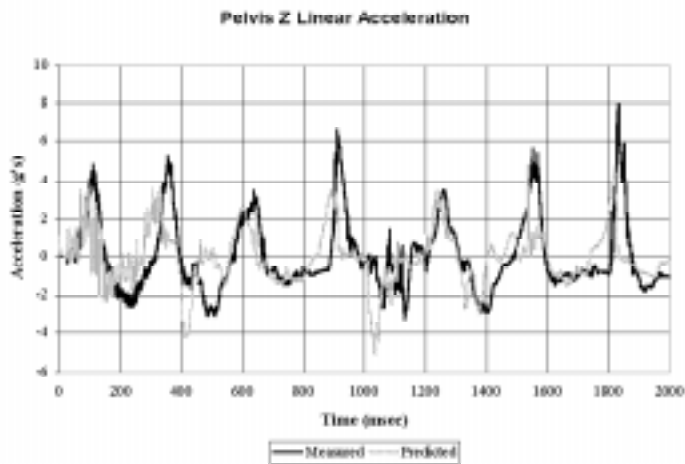**UNDERWATER EXPLOSION**, *continued from page 35*

Figure 7. Comparison of pelvis Z acceleration

Simulation Model for Human Male and Female Responses

The validated model of the chair and input excitation was used for predicting the response of a 50th percentile human male (5'10" tall, 173.5 lbs.) and of a 5th percentile human female (5' tall, 100 lbs.) in three separate situations. The first simulation was very similar to that of the Hybrid III dummy in the original test. The lap belt was still fastened, but the arms were positioned more naturally. The second simulation was with the lap belt removed and a desk surface placed in front of the chair. The position of the subjects was identical to that in the first simulation. The final simulation was the same as the second, but surfaces representing a computer keyboard and monitor were included. For each of these cases, the simulation was performed for both the male and the female human subjects.

Description of Injuries and Injury Criteria

The only injuries for which estimates were performed for the seated subjects were those of the head and head-neck complex, specifically cerebral concussion, whiplash, fractures of bones of the face or skull, and injuries to the cervical spine due to axial loading. These specific injuries were considered to be not only the most likely to be sustained but also those that would be most debilitating in the near or long term. Various parameters of the predicted response, as described below, were compared against their associated injury threshold values and estimates made of the likely injuries for each of the subjects.

Cerebral concussions that, according to *Taber's Cyclopedic Medical Dictionary* [5], have associated symptoms of transient dizziness, paralyses or unconsciousness, unequal pupils, shock, vomiting, rapid pulse, headache, and cerebral irritation, were evaluated by comparing the angular velocities and accelerations of the center of gravity of the head against the corresponding injury tolerances. According to Ommaya [6], the crucial injury mechanism leading to the onset of cerebral concussion is severe shear strain imposed by brain rotation and the proposed thresholds to predict a 50 percent probability of the onset of cerebral concussion in terms of angular velocity is 50 rad/sec, and in terms of angular acceleration is 1800 rad/sec^2. Thus, the resultant angular velocities and accelerations of the center of the head as predicted using the ATB program were plotted and compared to these threshold values to estimate the likelihood of the subject receiving a cerebral concussion.

Whiplash, which is a somewhat vague term referring to the broad collection of acceleration induced traumas to the cervical spine, is typically associated with rear end automobile collisions. In these instances, the body experiences a sudden forward acceleration, while the inertia of the head keeps it stationary. The force applied by the torso to the lower portion of the head causes a rotation of the head, resulting in an extension of the cervical spine. If the acceleration is sufficient, the inertial loading of the cervical spine can result in hyperextension and a whiplash injury. Kallieris [7] notes that restraining the torso during a deceleration event (such as a frontal collision) can lead to a hyperflexion of the cervical spine and an associated whiplash injury. Thus, the key components are excessive angle of the neck with respect to the torso, either in flexion or extension, combined with tensile loading. As reported in Panjabi and White [8], possible angular position thresholds are 80 degrees in extension and 58 degrees in flexion. Mertz and Patrick [9] claim that the torque developed at the occipital condyles (the point at which the skull articulates with the cervical spine) is a better predictor of whiplash injuries and that appropriate tolerance values are, for extension, 35 ft-lb (injury) and 42 ft-lb (ligamentous damage), and, for flexion, 44 ft-lb (pain), 65 ft-lb (injury), and 140 ft-lb (ligamentous or bone damage). Thus, for this research, the head angular position with respect to the torso predicted using the ATB program was considered to be a weak indicator for whiplash injury and the torque at the occipital condyles, also predicted using the ATB program,

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was considered to be a strong indicator for whiplash injury. In all cases, the axial force within the neck was checked to verify that the loading was tensile.

Potential fractures of the bones of the face and skull were estimated by comparing the contact forces between the head segment and the desk or computer surfaces as computed using the ATB program against the respective fracture thresholds. The particular bone in question was estimated by close examination of the visualization of the motion generated using the IMAGE program. For each contact, the portion of the ellipsoid representing the head, which was in contact with the desk or computer, was associated as nearly as possible to the corresponding bone in the face or skull. The contact locations considered in this study and their associated threshold fracture forces, as summarized in Allsop [10] are: frontal, 900 lbf; temporo-parietal, 450 lbf; zygomatic, 225 lbf; maxilla, 150 lbf; anterior-posterior mandible, 400 lbf; and lateral mandible,

200 lbf.

Significant injuries to the cervical spine due to axial loading, such as vertebral body fractures, facet dislocations, disk ruptures, and longitudinal ligament tears, were estimated by comparing the predicted axial load in the neck, along with the associated relative position (flexion, neutral, or extension), against the associated tolerance values. The neck axial load was computed from the forces in the joints between the upper torso and neck and between the neck and head. These joint forces were directly computed using the ATB program. Compression loading injury threshold forces as summarized in Sances, et. al. [11] are 6000 N for pure compression, 2000 N for compression-flexion, and 2200 N for compression-extension. These position specific tolerances were used in conjunction with duration of loading curves for pure compression provided in AGARD [2]. Tensile loading injury threshold forces as summarized in McElhaney and Meyers [12] as 1450 N for pure tension and 1160 N for tension-extension. As was the case for compression loading of the cervical spine, the previously listed threshold forces for tension loading were used in conjunction with the duration of loading curves for pure tension provided in AGARD [2].

Table 1 provides a summary of the injury criteria used in this research, along with the associated source for each predicted response and estimated injury potentials.

The predicted motions of the male and female subjects wearing the lap belt show that each subject went through multiple rebounds of the torso off the upper legs during the two seconds of the shock excitation. During the first rebound, occurring at approximately 380 msec, each of the subjects are likely to receive a whiplash injury and possibly a cerebral concussion. The male subject's head reached a peak

Table 1. Summary of Injury Criteria

Injury	Criteria	Source
Cerebral concussion	$\omega \geq 50$ rad/sec $\alpha \geq 1800$ rad/sec^2	Ommaya, et.al., [6]
Whiplash (extension)	$\theta \geq 80$ deg	Panjabi and White [8]
	35 ft-lb (injury) 42 ft-lb (ligamentous damage)	Mertz and Patrick [9]
Whiplash (flexion)	$\theta \geq 58$ deg	Panjabi and White [8]
	44 ft-lb (pain) 65 ft-lb (injury) 140 ft-lb (ligamentous or bone damage)	Mertz and Patrick [9]
Skull fracture	900 lbf (frontal) 450 lbf (temporoparietal)	Allsop [10]
Facial fracture	225 lbf (zygomatic) 150 lbf (maxilla) 400 lbf (anterior-posterior mandible) 200 lbf (lateral mandible)	Allsop [10]
Cervical spine injury due to axial loading (compression)	6000 N (pure) 2000 N (flexion) 2200 N (extension)	Sances, et. Al., [11]
	Duration of loading curve	AGARD [2]
Cervical spine injury due to axial loading (tension)	1450 N (pure) 1160 N (extension)	McElhaney and Meyers [13]
	Duration of loading curve	AGARD [2]

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angle in flexion of 91.8 deg at 398 msec, with an associated torque at the occipital condyles of 44.1 ft-lb reached at 389 msec, and experienced a peak angular acceleration of 2242 rad/sec^2 at 388 msec. The corresponding injury threshold values are 58 deg [8], 44.1 ft-lb for pain [9], and 1800 rad/sec^2 [6]. The female subject's head reached a peak angle in flexion of 87.8 deg at 386 msec, with an associated torque at the occipital condyles of 30.2 ft-lb reached at 389 msec, and experienced a peak angular acceleration of 1903 rad/sec^2. During subsequent rebounds of the torso off the upper legs, additional whiplash injuries are possible based solely upon the angle of the head. The male subject's head reached peak flexion angles of 63.0 deg at 1020 msec and 79.1 deg at 1851 msec, during the second and fourth rebounds, respectively, while the female subject's head reached a peak flexion angle of 74.8 deg at 999 msec during the second rebound.

The motion of the male and female subjects when not wearing the lap belt, but seated at a bare desk, were also predicted. Since the desk is present, each subject experienced multiple impacts of the head against the desk rather than rebounds of the torso off the upper legs. During the first head to desk contact, each subject would possibly receive a cerebral concussion based on head angular accelerations in excess of the 1800 rad/sec^2 tolerance value [6]. The male subject experienced a peak acceleration of 2109 rad/sec^2 at 431 msec and the female subject experienced a peak of 074 rad/sec^2 at 346 msec. The female subject would possibly receive additional

injuries during the first head to desk contact. The female subject experienced a peak axial load in the neck of 1614 N at 344 msec, which slightly exceeds the threshold for significant neck injury [13], and a contact force between the lateral mandible and the desk of 390 lbf, which exceeds the 200 lbf fracture threshold for that bone [10]. During the second head to desk contact, the male subject experienced a peak contact force between the maxilla and the desk of 465 lbf, which exceeds the 150 lbf fracture threshold for that bone [10] and would likely result in fracture. The female subject experienced a peak head angular acceleration of 1984 rad/sec^2, which slightly exceeds the 1800 rad/sec^2 threshold [6] and would possibly result in a cerebral concussion. The male subject experienced a third head strike with a peak contact force between the zygomatic bone and the desk of 309 lbf, which exceeds the 225 lbf fracture threshold for that bone [10] and would possibly result in fracture.

The predicted motions of the male and female subjects not wearing the lap belt, but seated at a desk with a computer, are similar to the unbelted case. Each subject experienced multiple head strikes, but this time against the computer. Examining the predicted response parameters of the male subject revealed none in excess of the corresponding thresholds. Thus, the male subject is not likely to receive any of the injuries considered in this research. No consideration was made of possible lacerations resulting from breaking of the computer screen during impacts, so no prediction can be made of the likelihood of the male subject receiving this type of injury. The female subject experienced peak angular accelerations of 1880 rad/sec^2

during the first head strike against the computer, and 2427 rad/sec^2 during the second. The angular acceleration experienced during the first contact slightly exceeds the 1800 rad/sec^2 threshold value (Ommaya, et. al., 1993) and would possibly result in a cerebral concussion. The angular acceleration during the second peak is well in excess of 1800 rad/sec^2 and would thus be likely to result in a cerebral concussion. During the second head to computer contact, the female subject also experienced a peak contact force between the zygomatic bone and the computer of 360 lbf, which exceeds the 225 lbf fracture threshold for that bone (Allsop, 1993) and would possibly result in fracture. Additionally, during the second head to computer contact, the female subject experienced a peak axial loading of the neck of 2605 N (compression-extension) which exceeds the 2200 N threshold for significant neck injury "Sances" (Sances, et. al., 1986).

A summary of the estimated injuries for the six subjects is provided in Table 2.

Conclusions
On the basis of the presented results, it is concluded that: i) the Articulated Total Body model is a viable tool for simulating both male and female personnel in various positions in a shipboard environment during underwater explosion events; ii) significant injuries can be expected for both male and female subjects in a shipboard environment subjected to a shock induced excitation; and iii) the selection of application of injury criteria to predicted motion is extremely complicated.

FEATURED PROJECT

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Additional information can be found at http://www.nps.navy.mil/~code09/faculty.html

References
1. Obergefell, L.A., et. al., 1988, "Articulated Total Body Model Enhancements Volume 2: User's Guide," AAMRL-TR-88-043.

Table 2. Summary of Injury Estimates

		Time (msec)	Parameter	Value	Limit	Outcome
Belted Subjects	**Male**	388	Head α	2242 r/s^2	1800 r/s^2	Possible cerebral concussion
		398	Head θ	91.8 deg	58 deg	Probable whiplash injury
		389	Torque	44.1 ft-lb	44 ft-lb	Probable whiplash injury
		1020	Head θ	63.0 deg	58 deg	Possible (not likely) whiplash injury
		1851	Head θ	79.1 deg	58 deg	Possible (not likely) whiplash injury
	Female	379	Head α	1903 r/s^2	1800 r/s^2	Possible cerebral concussion
		386	Head θ	87.8 deg	58 deg	Probable whiplash injury
		389	Torque	30.2 ft-lb	44 ft-lb	Probable whiplash injury
		999	Head θ	74.8 deg	58 deg	Possible (not likely) whiplash injury
Unbelted Subjects	**Male**	431	Head α	2109 r/s^2	1800 r/s^2	Possible cerebral concussion
		1257	Head cont. force	465 lbf	150 lbf	Possible fracture of the maxilla
		1917	Head cont. force	309 lbf	225 lbf	Possible fracture of the zygomatic
	Female	346	Head α	2074 r/s^2	1800 r/s^2	Possible cerebral concussion
		983	Head α	1984 r/s^2	1800 r/s^2	Possible cerebral concussion
		346	Head cont. force	390 lbf	200 lbf	Possible fracture of the lateral mandible
		344	Neck axial force	1614 N	1450 N	Possible significant neck injury
Subjects at Computer	**Male**		No injury tolerances exceeded. Potential exists for lacerations resulting from possible breakage of computer screen during direct head impact.			
	Female	340	Head α	1880 r/s^2	1800 r/s^2	Possible cerebral concussion
		1178	Head α	2427 r/s^2	1800 r/s^2	Possible cerebral concussion
		1189	Head cont. force	360 lbf	225 lbf	Possible fracture of the zygomatic
		1189	Neck axial force	2605 N	2200 N	Possible significant neck injury

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2. AGARD, *Anthropomorphic Dummies for Crash and Escape System Testing,* AGARD Advisory Report 330, 1996.
3. Cheng, H., et. al., 1994, "Generator of Body Data (GEBOD) Manual," AL/CF-TR-1994-0051.
4. Oglesby, D.B. and Shin, Y.S., *ATB Program and Its Applications to Biodynamic Response Simulation of Underwater Explosion Events*, Technical Report NPS-ME-98-002, Naval Postgraduate School, Monterey, CA, March 1998.
5. Thomas, C.L., ed., *Taber's Cyclopedic Medical Dictionary*, F.A. Davis Company, Philadelphia, PA, 1993.
6. Ommaya, A.K., et. al., "Comparative Tolerances for Cerebral Concussion by Head Impact and Whiplash Injury in Primates" S.H. Backaitis, ed., *Biomechanics of Impact Injury and Injury Tolerances of the Head-Neck Complex*, Society of Automotive Engineers, Warrendale, PA, 1993, pp. 265-274.
7. Kallieris, D., et. al., "Considerations for a Neck Injury Criterion," The 35th Stapp Car Crash Conference Proceedings, Society of Automotive Engineers, Warrendale, PA, 1991, pp. 401-417.
8. Panjabi, M.M. and White III, A.A., "Biomechanics of Spinal Injuries," A. Sances, Jr., et. al., eds., *Mechanisms of Head and Spine Trauma*, Aloray, Goshen, NY, 1986, pp. 237-264.
9. Mertz, H.J. and Patrick, L.M., "Strength and Response of the Human Neck" in S.H. Backaitis, *Biomechanics of Impact Injury and Injury Tolerances of the Head-Neck Complex*, Society of Automotive Engineers, Warrendale, PA, 1993, pp. 821-846.
10. Allsop, D., "Skull and Facial Bone Trauma: Experimental Aspects," A.M. Nahum and J.W. Melvin, eds., *Accidental Injury: Biomechanics and Prevention*, Springer, New York, NY, 1993, pp. 247-267.
11. Sances, A., Jr., et. al., "Spinal Injuries with Vertical Impact," A. Sances, Jr., et. al., eds., *Mechanisms of Head and Spine Trauma*, Aloray, Goshen, NY, 1986, pp. 305-348.
12. McElhaney, J.H. and Meyers, B.S., "Biomechanical Aspects of Cervical Trauma," A.M. Nahum and J.W. Melvin, eds., *Accidental Injury: Biomechanics and Prevention*, Springer, New York, NY, 1993, pp. 311-361.

STUDENT RESEARCH, *continued from page 19*

measures of performance (MOP) for decision-makers to assess the effectiveness of promising technologies. Two assessments were performed. The first experiment measures for effect in aircrew target recognition reaction time and accuracy using two different sensors – visible and infrared. An ANOVA of the measured reaction times data showed that aircrew using a visible sensor were significantly faster than aircrew using an infrared sensor. The second assessment involves aircrew cognitive model building during pre-mission planning using Mission Rehearsal Simulation (MRS) software. An ANOVA of the measured data revealed that aircrew who used the MRS software were significantly faster than aircrew who did not. An optimum aircrew training methodology using MRS software was devised and it is currently being integrated into F/A-18 fleet replacement squadron training.

21ST CENTURY SUBMARINE INFORMATION OPERATIONS
LT Scott R. Coughlin, United States Navy
Master of Science in Systems Engineering-September 1998
Advisors: Vicente C. Garcia, Jr., National Security Agency Cryptologic Chair, and CAPT James R. Powell, USN, Information Warfare Academic Group

The Unites States Submarine Force has a long and distinguished history of providing national decisionmakers with intelligence, surveillance, and reconnaissance services allowed by the unique access granted by the submarine's attribute of stealth. To maximize the effectiveness of our submarine fleet to continue to perform tomorrow's Information Operations (IO) mission requires evolution. This thesis explored how to best prepare our submarine fleet to perform Information Operations.

PROPULSION LAB, *continued from page 15*

From l984 through l986 the role of the TPL in support of NAVAIR changed from performing in and advising the 6.1 program, to performing in and contracting out 6.1 and 6.2 programs in air-breathing propulsion. This was in response to the Navy's goal of ensuring "transition" from research to near-term applications. In l987 TPL helped to draft and was included in the Navy's 20-year R&D plan for aircraft propulsion.

In l987-l989 an investigation of "controlled diffusion" compressor blading in the Low Speed Cascade Wind Tunnel was funded by NASA Lewis Research Center. The goal was to verify a design process that generated "optimized" compressor blade shapes that were free of flow separation at high loading. Through a succession of seven students, the facility was set up and verified for compressor blade investigations and the reference double-circular arc blading was scaled, built and tested, and then the equivalent controlled diffusion (CD) blading was tested. The design method for the CD blading was verified. A subsequent Ph.D. dissertation by Y. Elazar resulted in the first complete and detailed study of 2D viscous flow through a CD compressor cascade at increasing inlet flow angles.

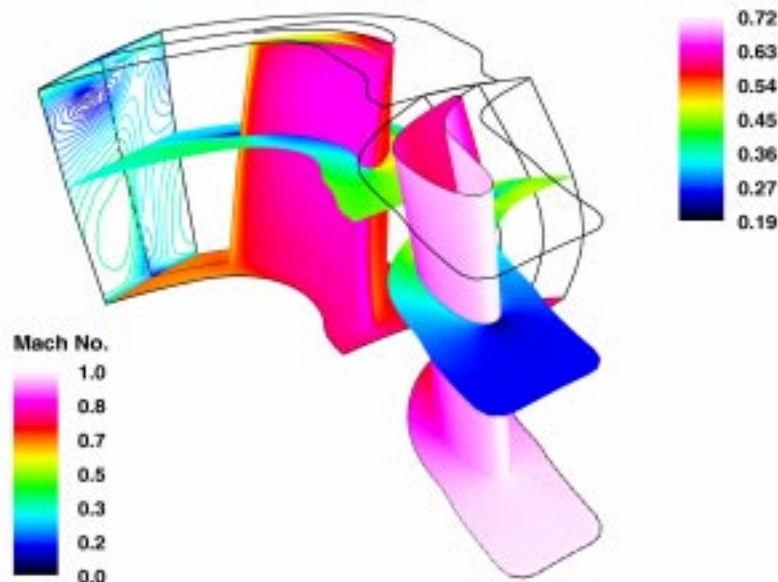Associate Professor **Garth Hobson** joined the Department of Aeronautics and Astronautics in l990, bringing, in addition to a current knowledge of CFD and strong interests in gas dynamics and propulsion, nine years of practical experience at South Africa's equivalent of NASA. **Rick Still**, who had become the GDL technician in 1989, brought to the group the initiative and skills that were required to provide the technical support that was needed.

Since 1990, the Navy has been in a process of reduction and reorganization. TPL has built an active program by responding directly to the program needs of the Propulsion and Power Engineering organization at NAWCAD, the Joint Program Office for Cruise Missiles and UAVs and DARO. From l990 through l998 forty-six students have graduated, thirty papers with thesis students were presented, and sixteen papers were published.

Recently completed efforts include:

• Compressor Tip-Clearance Effects – A Ph.D. dissertation study carried was out by Ian Moyle over several years using the Low Speed Multi-Stage Axial Compressor in Bldg. 213. Moyle received his doctorate at the University of Tasmania under Greg Walker, a former NAVAIR Research Chair Professor at TPL.

• Controlled-Diffusion Blading – Separation and stall were examined at higher incidence angles, and 3D and unsteady data were obtained using the 'first generation' CD blading. A second-generation (much more highly loaded) CD cascade is currently installed, and CFD predictions of the viscous behavior are being evaluated.

Pressure
0.72
0.63
0.54
0.45
0.36
0.27
0.19

Mach No.
1.0
0.8
0.7
0.5
0.3
0.2
0.0

CFD Results for Space Shuttle Main Engine / Alternate Fuel Pump Turbine

• Shock-Boundary Layer Interaction in a Fan Passage – The flow through a transonic fan passage at M=1.4 was simulated in a 2D blow-down supersonic cascade wind tunnel which was built in the Gas Dynamics Laboratory. The attempt was then made to reduce losses using 'low-profile' vortex generators. The work helped provide the propulsion manager at NAVAIR with an informed technical assessment of an exploratory development program for low-profile vortex generators being funded at Pratt & Whitney.

The Integrated High-Performance Turbine Engine Technology or IHPTET Program, involving industry with the sponsoring government agencies, was initiated in the mid 80s. The fan and
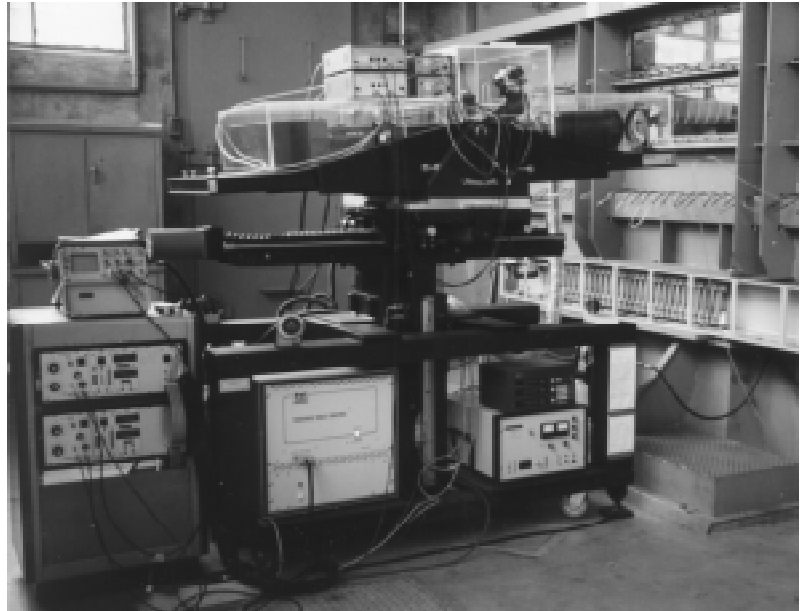
PROPULSION LAB, *continued from page 40*

compressor and turbine programs at TPL support elements of the Navy's participation in IHPTET (and component improvement programs), contributing research expertise and conducting specific fan and turbine investigations for which the Laboratory is uniquely equipped. Also, two years ago, a national initiative was organized on the problem of high-cycle fatigue (HCF) in engine components. Patterned after the successful IHPTET program, the goal is to reduce the incidence of engine failures caused by HCF. Since the Navy's rotor spin test activity (recently moved from Trenton to NAWCAD at Patuxent River) is unique in the military, it will play a significant role in the Navy's participation in the HCF initiative. In support, a research activity has been initiated at TPL which is fully integrated into the NAWCAD's HCF effort. Finally, uninhabited aerial vehicles are recognized as a direction for the future, and efficient small engines are among the propulsion systems that are needed. A study of small gas turbine engines was therefore initiated at TPL.

Low-Speed Cascade Wind Tunnel and Traversing LDV System

Current programs at TPL include:

• Advanced Fan & Compressor Design - A "code validation" transonic axial stage was designed by NASA Lewis Research Center for TPL's test rig. The numerically-machined bladed-disk rotor and controlled-diffusion stator were successfully tested in 1997 to 80% of design speed by a student, **LT Bart Grossman**. The flow through the rotor, which has been computed independently at TPL using NASA's RVC3D code, as well as the flow at the rotor exit, will now be measured. Major Hazem Abdelhamid, in a Ph.D. dissertation, showed that you can represent fan blade shapes analytically by specifying only 32 control points and two additional parameters (to control leading edge and trailing edge sharpness). Using CFD analysis, he obtained results for the effect of forward and aft sweep on the performance of the NASA Lewis rotor.

For more information on the Turbopropulsion Laboratory visit the AA Department's home page at www.aa.nps.navy.mil.

• Turbine Tip Clearance Flows - Professor Hobson and his students have taken a number of steps towards the goal of validating turbine flow field predictions. First, the turbine test rig was rebuilt to house the Space Shuttle Main Engine alternate fuel-pump turbine as a research test bed. They then obtained unsteady LDV data in the rotating

machine environment. They have also been successful in working out the problems of obtaining accurate measurements in highly swirling flows near to walls.

• HCF/Spin Test Research - The program at TPL is an integral part of the Navy's participation in the High-Cycle Fatigue initiative. There is currently no fully adequate procedure for exciting and measuring blade vibrations in conventional spin tests. The purpose of the TPL program is to develop and/or evaluate blade vibration excitation and measurement techniques and help transition the expertise to production testing at NAWCAD. At the center of this effort is a large spin pit facility in Bldg. 215 in which rotors up to 56-inches in diameter can be tested.

In recent years, experimental programs in engineering have become extremely costly, and computer-simulation activities have proliferated in their stead. Few professors at universities have continued to do experimental research, and therefore the production of engineers with the background necessary to work effectively in test and evaluation has dropped precipitously. In this situation, the well-equipped and research-active propulsion laboratories at NPS, firmly tied to the School's educational mission, have become unusually valuable in-house resources for the Navy and DoD.

Conferences/Meetings at the Naval Postgraduate School

Date	Title	Sponsor
19-23 Oct 98	1998 Advanced Studies Institute Symposium (UNCLAS)	NPS, International Advanced Studies Institute, Naval Surface Warfare Center-Coastal Systems Station
12 Nov 98	National Security Affairs Conference (UNCLAS)	National War College, NPS
17-19 Nov 98	1998 AIAA Missile Sciences Conference (SECRET)	AIAA with Office of the Undersecretary of Defense (Acquisition and Technology)
26-28 Jan 99	IRIS Specialty Group Meeting on Targets, Backgrounds and Discrimination (SECRET)	Defense Logistics Agency
8-11 Feb 99	4th National Turbine Engine HCF Conference (UNCLAS)	Naval Air Systems Command
8-12 Mar 99	Hardened Electronics and Radiation Technology (HEART) Conference for 1999 (SECRET)	Defense Special Weapons Agency, Sandia National Laboratories, Air Force Research Laboratory, US Army Space & Missile Defense Command, Navy Strategic Systems Program Office
15-19 Mar 99	15th Annual Review of Progress in Applied Computational Electromagnetics (UNCLAS)	NPS, Applied Computational Electromagnetics Society
30 Mar-1 Apr 99	10th Annual U. S. Army Tank Automotive & Armaments Command Ground Vehicle Survivability Symposium SECRET)	American Defense Preparedness Association and Tank-Automotive and Armaments Command
4-6 May 99	National Defense Industrial Association 49th Annual Bomb and Warhead Technical Meeting (SECRET)	National Defense Industrial Association
4-7 May 99	Principles of Electro-Optical, Infrared and Laser Countermeasures (UNCLAS: 4-6 May) (SECRET: 7 May)	Association of Old Crows
22-24 Jun 99	45th Tri-Service Radar Symposium (SECRET/NOFORN)	Naval Research Laboratory
18-21 Jan 00	AIAA Strategic & Tactical Missile Systems Conference (SECRET/NOFORN)	American Instititute of Aeronautics and Astronautics
20-24 Mar 00	16th Annual Review of Progress in Applied Computational Electromagnetics (UNCLAS)	NPS, Applied Computational Electromagnetics Society

For additional information, contact the NPS Conference Coordinator, Elaine Christian, at 831-656-2426 or by e-mail echristian@nps.navy.mil

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as new military threats emerge and new technologies are introduced. The continuing research will develop and demonstrate systems for planning and execution that present all the participants a common operating picture in a seamless system that operates from planning through execution and that executes on computers in the planning activity and in the battlespace.

The live demonstrations of our systems for planning and execution offer dramatic visual proof that the dynamic, distributed advanced planning systems of the type envisioned in the Joint Vision 2010 and the Air Force's New World Vistas can be constructed today using commercial technology and our software architecture.

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